KRUPP
AND
DE BANGE

BY
E. MONTHAYE


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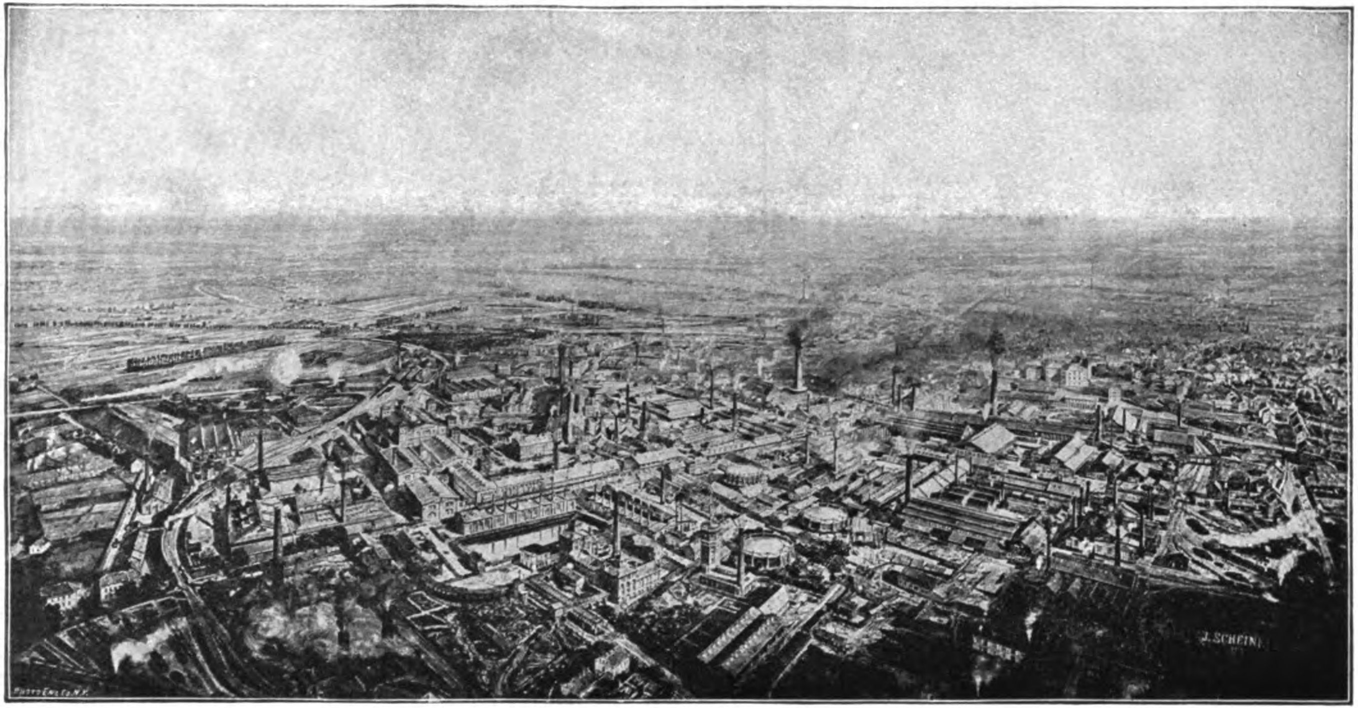

CAST-STEEL WORKS OF FRIED. KRUPP, ESSEN, GERMANY.

KRUPP AND DE BANGE:

BY

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CAPTAIN IN THE BELGIAN GENERAL STAFF.

TRANSLATED WITH AN APPENDIX,

BY

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American Introduction.

Belgium, owing to its peculiar political position as a neutral power, appears to have always a corps of officers who devote themselves to the exhaustive study of the various phases of their profession. Their investigations have ever received high consideration from us; in proof the names need only be cited of Bormann, Nicaise, Le Boulengé and others.

This fact alone, would secure for Captain Monthaye's work, interested American readers. Furthermore, at the present time when Armament is a question of paramount importance, everything that contributes to our knowledge of the subject must be opportune.

The text seeks to compare the two great European ordnance systems, the Krupp and the De Bange, systems that differ intrinsically in material, construction and breech-closure. The work gives valuable ballistic information and is of especial practical interest to us, as our new experimental high-power guns are of modified De Bange model.

Whatever individual opinions may be held, all must agree in praise and admiration of the wonderful man, Alfred Krupp, the father of modern steel-founding.

The appearance of the two-ton crucible steel cast ingot at the London Exhibition of 1851 was a revelation

to the metallurgical world. Krupp's continued success in increasing the size of his homogeneous crucible cast blocks, culminating just previous to his death, in the 70-ton ingots used for the tubes of the 120-ton Italian guns, undoubtedly stimulated inventive genius in this direction, and his work and its results contributed their share to the development of the Bessemer and Open-hearth processes.

No apology is required for presenting to an American public anything that concerns, directly or indirectly, a man to whom the whole world owes a debt of gratitude.

Kennebec Arsenal, July 1888.

O. E. MICHAELIS.

Preface to the First Edition.

Two systems of Gun construction virtually absorb the attention of steel makers and Ordnance officers; one, that of Krupp, has been known and practically tested for a number of years; the other, that of De Bange, adopted in France, is of comparatively recent origin.

If we may believe partisans of the De Bange gun, it has completely surpassed its German rival. Although this opinion, held mainly by interested persons, has not obtained general credence, it has a sufficiently strong foothold to render it an act of patriotism for a Belgian officer, on the eve of the day on which Belgium is to receive her new Krupp guns, to re-establish the truth and to restore to the Essen Constructor of Ordnance that pre-eminence which is his just due.

In treating of the attributes of the two systems, we base our statements entirely on facts and authoritative writings.

If, in the course of our studies, we have arrived at the conviction that the De Bange system is inferior to the Krupp, we have yet placed our readers in a position to appreciate the arguments on both sides and to decide for themselves as to the justice of our views; in this respect we believe our work is conscientious.

We have endeavored throughout to treat our opponents with courtesy and to abstain from personalities, useless as arguments. In accordance with this purpose, in the examination of the numerous works which have lately attempted to lower the reputation of Krupp in order to raise that of Colonel De Bange, we have inexorably cast aside those which are partisan pamphlets, rather than scientific arguments.

Let us speak one word of explanation in regard to the description of the Krupp establishment, published just after a visit to the Works at Essen, and reproduced at the end of this book.

Written on the spur of the moment, and bearing the same relation to a complete paper that an instantaneous photograph does to an engraving, it has exposed us to the reproach of "Krupp-worship" from those whom we, in our turn, might, did we feel so disposed, dub irritable "Krupp-haters."

There are, undoubtedly, people who esteem the De Bange gun a perfect construction. This is a privilege of which we could not deprive them, even had we the desire to do so; but we claim an analogous right, that of holding our own opinions of the Krupp gun.

In our description, we made no attempt to conceal that the finished methods, the wonderfully trained and expert mechanics, the enormous capacity of the Krupp Works astounded us, and that we firmly believed that this Age of Scientific Progress is deservedly proud of the great Engineer* who is the head of the plant, and of the able assistants who aid him in his Titan task.

* See Note on Page 166.

Though the charge of "youthful enthusiasm" may be brought against us, our readers must remember that *style* is but the clothing of the thought, changing with the fashion of the hour. We regret our faults of style; but we can state positively the essential point after all, that we have written only of *facts*, as they *are*, and of things *seen by us*. However desirous we might have been of avoiding everything that might tend to induce heated discussion, we could not do otherwise, even though it prove distasteful to those who believe that "words should conceal thoughts."

E. MONTHAYE.

Brussels, January 15, 1887.

Preface to the Second Edition.

The principles which have served as guides in the getting up of this work, principles which were announced in the preface to the first edition, have been recognized as sound in most of the many notices of the book. Some, however, have found fault, either with the method of treatment or with the arguments advanced. To these criticisms a reply has been made in a recently issued pamphlet, entitled "En cause de Krupp et De Bange." by Pertinax.*

The charge has been made that the texts and opinions of the distinguished metallurgists quoted in favor of crucible steel have been emasculated and perverted. This is not the case; we have condensed Frémy's views, carefully preserving the essence of his ideas; we have quoted Percy and Grüner as we understood them, and finally, in a sentence quoted from Valérius an "only" escaped our notice, with scarcely perceptible resulting change of sense.

A new edition of the book being required, the opportunity has been given us of correcting these so-called shortcomings, and we have gratefully availed ourselves of this opportunity to afford satisfaction to our opponents. We quote Frémy *verbatim*; we have left out the citations from Percy and Grüner, whose investigations,

* NOTE —A translation of the pamphlet will be found in the Appendix.

by the way, were made while the open-hearth process was still in its infancy, and we have done justice to Valérius.

Lieutenant Colonel De la Rocque was quoted as against open-hearth steel, and not as in favor of crucible, hence no apology is due him.

Although we are firmly convinced that the superiority of crucible over open-hearth steel is conclusively proved by the very methods of prodnction, a point which is briefly discussed by Pertinax, we have nevertheless deemed it best to adhere faithfully to our announced plan, to base our work upon the testimony of eminent and practical experts.

Having this in view, we have added some further authoritative statements, all enunciated within the past ten years, in confirmation of the views already put forth.

We find further support for our proposition in the bursting of the De Bange 34 centimetre gun, the one which was exhibited at Antwerp in 1885, and which was, so to speak, the occasion for the discussion into which we were subsequently drawn. This casualty occurred August 4th, 1887, at Calais, after very few rounds.*

Colonel De Bange ascribes the failure to a "weak spot" in the metal which he had observed during the finishing. We have no commentary to make, and we have not even changed our text in speaking of this gun, as it was, so that it might readily be seen upon what our opinions were founded.

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*NOTE.—An account of this accident, from the *Army and Navy Journal*, is given in the Appendix.

It only remains to express the hope that this edition of "Krupp and De Bange" may be received with the same good will that was accorded to the first, and that it may help in carrying out our proposed task, to enable our readers to form a correct judgement of the respective merits of the two systems of Ordnance construction at present before them in competition.

Brussels, February 15th, 1888.

E. M.

List of Works Consulted.

Cours d'artillerie et de chimie appliquée,
Artillery and Engineer School of Application,
Brussels.

Le métal à cannon, *Frémy*.

Traité théorique et pratique de la fabrication du fer et de l'acier, *Valérius*.

Traité de metallurgie, *Grüner*.

La métallurgie a l'Exposition de 1878, *Lan*.

La métallurgie du fer à l'Exposition universelle de 1878, *P. Duteil*.

L'acier fondu homogène, *Firth*.

Krupp's Rundkeil—Verschluss fuer Feldcanonen, ... } *Essen*.

Krupp's Rundkeil—Verschluss fuer schwere Geschuetze, ... } *Essen*.

Aide-mémoire d'artillerie.

Cours spécial a l'usage des sous-officiers d'artillerie.

Schiess—Versuche der Gusstahlfabrik Fried. Krupp auf ihrem Schiessplatz bei Meppen.

Étude historique de la résistance des canons rayés, *Lieut. Col. De la Rocque*.

The United States Gun Foundry Report.

Canons français et allemands, *Captain Mariotti*.

L'artillerie Krupp et l'artillerie De Bange, *Lieut. Col. Hennebert*.

Revue d'artillerie.

Revue maritime et coloniale.

Rivista di artiglieria e genio.

French and German Artillery Manuals.

Newspapers and Miscellany (*The Times*, *The Engineer*, *La France militaire*, *Deutsche Heeres-Zeitung*, *&c.*)

KRUPP AND DE BANGE.

"The quality of the metal, the details of manufacture, the disciplined exactness of treatment, the practice and the transmitted methods of the workshop, all these play a most important part in determining the strength of guns."

Historical Study of the Strength of Rifled Cannon, by Lieut.-Col. DE LA ROCQUE. Baudoin & Co., Paris, 1885.

Although Ballistics is an exact science, built upon fixed foundations, the practical application of its principles varies unceasingly. As we understand it, freed from the fettering traditions of the ancient art of gunnery, it is, under the influence of new researches and experiments, a continually expanding science, and only a foolhardy man would assert that the logical conclusions of to-day will possess equal force to-morrow. It follows that any State, anxious to preserve its military standing in comparison with its neighbors, is, by this continued development, compelled to renew its armament, possibly oftener than desirable, by adopting later and better material. This requirement is of paramount importance to the smaller States, who cannot hope to maintain their independence, or to defend their honor, unless their arms and equipments are not inferior to those of their possible adversaries.

Among the many considerations that bear upon the adoption of a system of heavy armament, two questions first of all present themselves to the intelligent ordnance expert:

First. What is the best metal for guns?

Second. What system of construction will yield the best result?

The discussion of these two questions constitutes Part First of this book. Part Second is devoted to a critical examination of the Krupp and De Bange systems, and to the investigation of the technical methods pursued in France and at Essen. Part Third includes a description of the Krupp Works, a natural conclusion to this monograph.

PART FIRST.

CHAPTER I.

Gun-Metal.

I.—Its Properties.

All gun-metal, according to the books, must possess strength and elasticity, must be able to resist erosion, to withstand heat, and to permit but little set under shock beyond the elastic limit. It is needless to attempt rigorous proof of the necessity of these conditions. It is sufficient to indicate that the expansive force of fired powder, the enormous pressures developed within the bore, and the consequent tendency to enlargement, the resulting gutterings if the material be not adequately hard, and finally the balloting of projectiles not mechanically fitted, all combine to demand that the structural material should possess the qualities mentioned.

Some authorities are of opinion that the cost of the gun metal should also be considered. This certainly has played a prominent part in official estimates, and is, of course, a matter of vital importance to the tax-payers. Economy should characterize the military, as well as

every other Government service; but with gun-metal, more than anything else, *endurance* is a function of quality, and hence it follows that a true economy requires the construction of guns of even expensive metal, provided longevity is assured. This question of cost is, at best, but secondary, considering the great interests involved.

Both theory and practice have shown that the molecular tensions in a gun, under the confined action of fired powder, decrease rapidly from interior to exterior, so that the outside laminæ are but little strained. But the pressure, as a *force*, must be in equilibrium with the tension of the circular fibres as *resistance*; it follows, then, that the interior fibres are enormously strained.

Now, if the first of these is stretched beyond a known limit, its power of resistance is impaired, rupture may ensue and extend outward, progressively, from fibre to fibre. As the transmission of rupture is gradual, it is useless to add metal on the outside; even were we to make the walls infinitely thick, the evil would not be cured. There is only one way of overcoming it: the exterior fibres must be made to do their share of the work; the law governing the transmission of strain must be modified by the radial compression of the fibres. This is what is intended to be accomplished by *hooping*, a generally recognized principle. We may add, then, to the conditions already enumerated, gun-metal must be capable of enduring *initial tension.*

There are metallurgists and ordnance officers who invest gun-metal with other more abstruse and specific attributes, but the limits assigned to this work forbid their consideration here, and allow the discussion of only those which are generally demanded.

With this reservation we will examine the various gun metals used, with a view of determining the one that possesses, in the highest degree, the qualities indicated.

II.—Cast and Wrought Iron, Ordinary and Uchatius Bronze, Steel.

Cast-iron is neither very strong nor elastic under strains of extension, but, on account of its hardness, powder gases and heat affect it but slightly, and it shows appreciable contraction under hooping. It has, though, one very grave fault: it bursts, often without the slightest notice, as soon as the elastic limit is passed. Wrought iron is strong, more elastic than cast-iron under extension and less under compression, but hooping does not produce initial tension. Although it stands fairly well the action of powder gases and high temperature, still it is a comparatively soft metal and lacks homogeneity.

Bronze possesses a remarkable property, it does not burst even when its elastic limit is far exceeded; in this respect it is just the metal for guns, but, unfortunately, in every other way, it is entirely unfit. It is soft, yields most readily to the erosive action of gases at high temperatures, and cannot be advantageously hooped. As an alloy it is rarely homogeneous, mainly due to the fact that the copper and tin have not been sufficiently refined, and therefore are not combined under the most favorable conditions.

Bronze, swaged as practiced by Uchatius, gains greatly in power of resistance and elasticity, and is still used for certain types of guns.

Steel, the last in our list, makes the strongest, the most elastic, the toughest gun metal. It is readily subjected to initial tension, resists erosion and stands heat; it is the typical *gun-metal,* and has been accepted as such in all services, not even excepting England and France. These nations fought long against its use, but, after costly experience, were compelled to acknowledge its incomparable qualities. Although cast-iron and bronze are still used for guns, temporary make-shifts,

because steel is high-priced, it is obvious that, as appropriations increase, steel replaces every other metal. Such astonishing progress has been made lately in the production and treatment of steel, that no prophet is required to predict that in the near future cast-iron, whose sole merit is cheapness and easy manipulation, will be an unknown metal in gun construction.

III.—Varieties of Steel, Frémy's Gun-Metal.

There are many ways of making steel, and as its properties vary according to the method of production, it becomes a matter of importance to choose the right one for gun steel.

Bessemer, Open-hearth and Crucible steel are used for cannon, though Bessemer, for this especial purpose, appears to be going out of use.

Open-hearth steel is coming into general favor, especially in France, and Crucible steel is used in England, and very largely in Germany.

Puddled or semi-steel is used only for hoops, and is mentioned here, because it plays an important part in the production of high quality steel, insuring homogeneity in proportion to the rigor of the refining process through which it has passed.

We propose to examine with care the special characteristics of these steels, and, in the course of the examination, we shall have frequent occasion to quote the opinions of distinguished authorities, like Frémy, Valérius and others, who have made a study of the subject, and whose conclusions possess great weight.

To these opinions we propose to add the testimony of practical steel makers, whose exhaustive experience makes their utterances authoritative.

First, let us quote Frémy, whose works on steel production and its attendant phenomena are too well known to need our praise.

After the Franco-German war, at a time when his native land was making every possible effort to improve its military organization and weapons, this distinguished chemist, determined to add his mite to the good work, submitted to the War Department certain theoretical results regarding steel production, and recommended that the method proposed be subjected to practical tests, being certain that it would yield an excellent gun-metal. This recommendation was approved, and Frémy set to work.

He undertook an extended series of experiments in making steel, having the valuable assistance of one of the brightest Ordnance officers in France, Captain Lahitolle.

His report, published under the title, "Gun-Metal," (Paris, 1874), is still the most complete work on the subject, and this report we propose to analyze and discuss.

The author says in his preface, "practical experience has proved the correctness of my conclusions."

We have to do then, not with merely a theoretical treatise but with a manual, written for Ordnance officers and gun makers.

"All steel experts," writes Frémy, "are well aware how difficult it is to assure a constant product; the characteristics of the metal change markedly with slight variations in the processes of manufacture, and hence the output must be classified for use, a delicate and difficult task."

After dwelling somewhat upon the well understood uncertainties that hamper the manufacture, Frémy gives the method by which he reached the best, the most constant results. It is, in brief "to combine by simple melting, iron and steel."

"I had in view," he continues, "making gun-metal like an ordinary alloy in which the components, pure of course, are chemically united by fusion."

Our learned professor adds ; "I have found that an excellent gun-metal is obtained by alloying three parts of iron with one part, good measure, of high steel ;" the very method followed by Krupp in making his Crucible steel, though the exact proportions are not known.

Having determined upon the alloy, where shall we get the components ? As regards iron, the product of the Catalan forge is undoubtedly the purest, but the cost is great, the output limited ; but Grüner, in his treatise on Metallurgy, tells us that "by puddling, we can now get as good a product as that from the Catalan furnace, at considerably less cost."

As an iron of that exceptional quality was out of the question, Frémy fell back on the less pure *commercial irons*, gained as indicated by Grüner, and recommends as one component of the gun-metal alloy, the puddled iron made from good charcoal pig.

IV. Puddled or Semi-Steel.

The other component is *steel.* Frémy considers its controlling characteristic, purity, and as the importance of this quality as regards iron has already been shown, no one will gainsay him, it is a matter of course. The whole question hinges on our ability to get pure steel. Steel can be made by decarburizing pig, or by recarburizing wrought iron.

This latter, a cementation process, yields *cement* or *blister steel*, the choicest brand, provided the very best pig has been used in puddling, and the utmost skilled attention given to the details of the process.

Blister steel is not made in great quantity, and it costs too much for general consumption. The next best method of making pure steel is by puddling, but stopping short at the proper carbon point.

"*Puddled steel,*" says Frémy, "though made di-

rectly from the pig, has and always will have its industrial uses, and if made with all possible care of first-class pig, is of excellent quality and very often superior to that made by other processes." In the manufacture of this steel, as in any other, the selection of the pig is of paramount importance. On this point Frémy speaks very decidedly ; " Most important of all, use suitable pig metal ; reject all having an excess of sulphur and phosphorus, give preference to that containing manganese, for this metal besides helping to eliminate impurities by slagging, increases the strength of the steel."

For puddling, Krupp uses pig, exceedingly rich in manganese, smelted at the Siegen mines.

" The actual work of the puddler," in the words of Frémy, " has a marked effect upon the quality of the resulting steel.".

Krupp has a school for puddlers, which accounts for the high esteem in which his workmen are held, even in England, the motherland of the process.

First-class puddlers, working good manganiferous pig, will produce superior steel. " Puddled steel," concludes Frémy, " worked with the greatest possible pains, and 'assurance made doubly sure' by rigorous chemical analysis, is a suitable component of the ferrous gun-metal alloy, it will certainly add strength to resist the great pressures of fired powder. I have no hesitation in asserting that good puddled steel can replace in certain proportions cement steel in a gun-metal mixture."

The views of this learned writer have been confirmed in practice ; at Essen, and at other plants where superior crucible steel is made, puddled steel forms a good part of the charge.

V.—Bessemer Steel.

As a gun-metal, Bessemer steel, as at present made, need not be seriously considered. In this process, the

pig, first decarburized by an air blast, is then, by the addition of manganiferous iron to the charge, converted into steel, high or low, as may be desired. This method has in late years been greatly modified and improved; many plants charge the converters directly from blast furnaces with Whitwell stoves, the pig metal being thus at once converted into steel.

"Can this metal be used in gun construction?" asks Frémy, and with him we will look into the matter.

"This question is of great moment to Ordnance officers, for Bessemer steel can be made quickly and cheaply, important considerations now-a-days; indeed it would cost no more for gun-metal mixtures than wrought iron. But the structural applications of Bessemer steel have a limit, and I confess I dare not recommend its use for gun-metal.

I have experimented a good deal with the converter, I have watched its working for months, I know how a low and strong metal can be obtained; still I must say that this process, so simple and direct, yielding almost at once, large ingots of cast-steel, does not yet guarantee that constancy of product, so absolutely essential in gun-metal."

Many things combine to make Bessemer steel irregular, and the converter does not permit the same examination of the ingredients as does the crucible, an inestimable advantage. The pig alone can be analyzed, and we all understand how little weight frequently attaches to the results.

As regards getting rid of impurities in the iron, it must be borne in mind that the charge is treated less than half an hour, that it consists of tons of metal, and that consequently the time must be too brief to insure the complete elimination of every thing injurious to strength.

"These detrimental circumstances," adds Frémy, "are of slight consequence in commercial steel, *but*

must be duly estimated in considering its use for gun-metal.

Bessemer steel develops under certain contingencies, a defect very serious when we consider it as a material for construction; it is frequently subject to a molecular change which makes it as fragile as badly annealed glass. I have seen Bessemer plates, of apparently good quality, crack all over as soon as used, and bars, which broke short off in falling a few feet.

Such a metal, if applied to gun construction, might stand all the inspection tests, but, owing to subsequent molecular change, might produce disastrous casualties."

We thus see how Frémy disposes of Bessemer steel as a gun-metal, but we must in fairness add that this opinion is accompanied by a proviso, a prudent precaution against what the future may have in store for us. "By continued careful study of the Bessemer process, I have no doubt but that the serious defects described will be overcome."

As we write, can the Bessemer steel makers in truth declare that they have cured the faults found by Frémy ten years ago?

We think not, and, at any rate, we know that but little has been used for guns. (1)

VI.—Open-hearth Steel.

In late years the Martin-Siemens furnace has become the rival of the Bessemer converter, and like it, affords opportunity for economically obtaining cast-steel in large masses.

It is a gas furnace, in which a very high temperature burns the carbon and impurities from the pig, yielding

(1) Note.—A 6 in. solid unhammered steel gun has just been successfully cast of Bessemer metal by the Pittsburg Casting Company, and will be tested as soon as finished. (O. E. M).

a homogeneous bath which is brought to the proper carbon point by the addition of spiegeleisen, ferro-manganese, or scrap metal.

"The Martin-Siemens process," says Frémy further, "is as economical as the Bessemer without its present drawbacks. The great trouble with the converter is that it works so very rapidly that it cannot produce a refined and homogeneous metal; the open-hearth bath, on the other hand, up to a given point, has all the merits of the crucible and the puddling furnace. * * * The construction of the furnace admits of watching the progress of the action, and the successive stages are known by the immediate test of specimens drawn at appropriate times. The leisurely open-hearth procedure necessarily gives a degree of purity and homogeneity, almost unattainable in the converter."

Although Frémy is convinced that the Martin-Siemens furnace can, under fit supervision, produce an excellent steel, suitable for guns, it is, however, only upon the condition that *a neutral atmosphere*, a *melting, not a refining*, atmosphere is attainable. He thus expresses himself in this regard:

"But, as yet, I entertain doubts as to its advantages for this purpose. So far, in my tests, the fusion of the metal bath has required an excess of pig-iron, subsequently decarbonized in the oxydizing atmosphere.

Further, the quality of the metal is *uncertain*, it varies with the more or less complete decarburization of the metal added to produce the bath. Considering this, the Martin-Siemens furnace is not merely a huge melting pot, it is a refining apparatus, akin to the puddling furnace and Bessemer converter, and in consequence, not free from their irregularity.

While awaiting the improvement of the open-hearth process, *it is safer to commence making gun-metal in*

crucibles; in this way, I made the alloys used in my principal experiments."

The author advocates the crucible process only as a temporary measure, in anticipation of the improvement of the regenerative furnace, but has the Martin-Siemens process fulfilled this hope?

We dare not answer in the affirmative, for it is an indisputable fact that at the close of the melt, ferro-manganese and ferro-silicon alloys must be added to the bath, a fact which proves that the furnace is still, as it was in Frémy's time, a refining apparatus, and that the essential condition, fixed by the French author, for its employ in gun-metal production, has not been realized.

Frémy's epitomized conclusions are very much to the point:

"1. The metal best adapted for gun construction is a special production ranging between wrought iron and high steel.

2. This metal may be obtained by the incomplete carburization of wrought iron, but the best way of producing it is to combine by fusion, one part of high steel with three parts of the iron.

This synthetic process, which recalls the ordinary method of making alloys, insures entire regularity; by varying the proportions, every degree of hardness required in ordnance constructions is attainable.

3. In its fabrication, the choice of proper brands of iron and steel, is a matter of paramount importance. The best brands of iron are the products of Catalan forges, or of charcoal refining furnaces using cold blast charcoal pig.

4. Coke brands should not be used in the production of gun-metal, unless it be impossible to procure good charcoal iron—in such case they should come from

first-class manganiferous pig, refined with all the care recommended.

5. The steel used for the gun-metal alloy should be, like the iron, as pure as possible, cement steel is best, then puddled, Bessemer and open-hearth.

6. The combination of the iron and steel should take place in a regenerative furnace ; but to start this new industry, I advise that the ingots be made of crucible cast metal.

7. The quality of the gun-metal is solely dependent upon the purity of its two constituents, iron and steel ; both these, before use, should be subjected to the most rigorous chemical analysis."

In his eighth and final conclusion, Frémy favors the manufacture of gun-metal by private industry.

For want of space, we cannot cite it here ; we quote only what the author says of Krupp, whom he holds up as a model to French manufacturers :

" Krupp guns are much talked about ; let us not forget that this constructor has succeeded in making for years, ordnance of world-wide reputation, because he follows a recognized scientific method. In his Works nothing is left to chance ; chemists are always busy analyzing ingredients and resulting products ; the scientific, the mechanical, and the military interests all work harmoniously together.

Ordnance officers are attached to the establishment and keenly follow every detail ; large sums are appropriated for tests of varying mixtures, possibly suitable for gun-metal, and an accurate record of each is kept, showing its chemical composition and its physical qualities."

VII.—Crucible Steel.

On Frémy's authority, it is proved that both theoretically and practically Crucible steel is best for gun-metal.

Professor B. Valérius, in his "Theoretical and Practical Treatise on the Manufacture of Iron and Steel" (Ghent and Leipzig, 1875), writes thus on crucible remelting:

"1. Remelting permits the testing, the choosing, the proportioning of the components.

2. Even should particles of slag or other impurities remain mixed with the steel, the slow fusion and the rest at a high temperature, will eliminate them.

3. This high temperature, added to the almost absolute purity of the liquid mass, divides up and disseminates the carbon uniformly, thus doing away with slight differences of hardness.

4. No injurious chemical change can take place.

5. The charge of each crucible being small (25 kilograms), proper supervision is possible, and uniform manipulation assured.

6. The maganese oxide added to the charge exerts a favorable catalytic influence.

On the other hand, crucible remelting is costly and difficult; the products of different crucibles vary, it requires a long apprenticeship to become expert; at Seraing there is not an employee capable of doing the work; and further, it has some of the inconveniences of the Bessemer process. Hence there is an increasing tendency to discard it."

This last paragraph shows the reason why the production of Crucible steel is undertaken by but a very limited number of makers.

The work is surrounded by so many difficulties, it must be carried on with such continued care and skill, that it is easy to understand failures and opposition.

In another part of his book, Valérius speaks still more decidedly: "As puddling eliminates portions of the sulphur and phosphorus contained in the pig, and as in the Martin-Siemens process a large amount of puddled iron is used, it follows that the same ores, used in the open-hearth furnace, must yield better steel than in the Bessemer converter, but *neither the one nor the other as yet holds out more than the hope of some day equalling, as regards quality of product, fusion in crucibles.*" Could anything be clearer or more decisive?

"At Krupp's Works," continues our learned professor, "there should be obtained," the author does not use the indicative, as he writes only of what he has heard and read, "by the remelting in hermetically sealed crucibles, a cast-steel free from blow holes; it is easy to see that this danger is less to be feared in crucible steel than in Bessemer, for the latter is permeated by the blast." And *we* add, "than in open-hearth, which is also produced by a conversion process."

Lan, Master ofMining Engineering, and Professor of Metallurgy at the School of Mines in Paris, follows Frémy and Valérius, and in his report, "Metallurgy at the Exposition of 1878," (Paris, 1879), thus expresses himself:

"The many attempts made since the introduction of the Bessemer and Open-hearth processes to utilize their products for tool steel have not as a rule led to satisfactory results. In Sweden and Austro-Hungary alone, partial success has rewarded these attempts, due undoubtedly to the excellent qualities of the components used in these countries.

Everywhere else, with varied proportions of components, only common tool steel has been produced, not for

a moment comparable with the beautiful bars of crucible steel exhibited by Sheffield and one or two French makers; pure carbon steels, running in carbon from 60 to 75, even to 150, but rarely more, perfectly classed, according to carbon point, into five or six, sometimes seven or nine, tempers, and labelled for the special use to which each temper should be applied. Tension tests are no longer used, now-a-days, to classify steel; it has long been known in well managed steel Works, that the results of tension tests are not satisfactory indices of the quality of tool cast-steel. We can cite more than one pulling test of Open-hearth or Bessemer mixtures, mixtures with carbon point from 90 to 100 or 120, with no more silicon than many crucible steels, but always with more maganese, mixtures, resulting from the fusion of puddled steel or of Bessemer, made of very pure, but coke and hot blast pig, mixtures, which *under pulling tests gave exactly the same resistance and elongation as certain crucible steels, and yet what a difference there was between the tools made from them!* The crucible steel tool, in the form of gravers, scissors, etc., keeps sound, while that made of hearth mixture dulls under blows, soon becomes notched, or breaks."

This statement is important from several points of view. First, it is clear that what is applicable to crucible tool steel is quite as applicable to gun steel, of the same make but much softer. Second, it shows that steel may possess qualities, determinable neither by tension tests nor by chemical analyses. The learned professor errs, however, in putting puddled steel as a raw product on the same footing with Bessemer, for it unquestionably offers greater guarantees of purity than the latter. An attentive study of Professor Lan's statements must lead to the conclusion that the crucible process alone assures, under similar conditions of chemical

purity, the possession of exceptional qualities by the product.

We can add to the testimony of these learned theoretical experts, the practical experience of numerous steel makers. We cite first Firth, the well-known Sheffield maker, who in a pamphlet, "Homogeneous Cast-Steel," published in 1872, wrote as follows:

"Cheap steels have found ready markets, and their general application for trade purposes, due mainly to their low price, marks an era in metallurgical progress, but we must not ask of them that which from their very nature they cannot grant. It is almost needless to say that they cannot compete with crucible steel for cannon and like exacting purposes. They are cheap, certainly an advantage, a very important one in many applications, but, so far as regards guns, a quality that may produce disastrous results.

"The best gun-metal is crucible steel, made of fine brands of iron. Composed of choice components, produced on account of its cost by selected workmen, it has the still further advantage over lower grades, of acquiring, under manipulation, new properties which constitute it the true steel for guns. It alone yields perfectly sound and homogeneous blocks.

Its cost is relatively high, easily explained, for no expense is spared to make it answer the purpose to which it is to be applied. The English Government wants no other grade, and the Firth Works furnish no other to gun makers and ship builders."

It must be admitted that since this was written, the Firth Works have been compelled to undertake the manufacture of Open-hearth steel, because from the very moment that the authorities declared themselves satisfied with hearth-made steel, Crucible steel, on account of its high cost, could no longer compete.

We have already given the reasons for believing that

the authorities do wrong in relying, in the inspection of their gun steel, upon ordinary physical tests, and we think that Firth's real views as regards Crucible steel are to-day the same as in 1872.

This sudden change of opinion on the part of the English Ordnance authorities is comparatively of recent date. In 1881 on the occasion of the visit of the "Iron and Steel Institute" to the Woolwich Gun Works, Colonel Maitland, at that time Director, thus expressed himself:

"The steel used for guns is procured by contract. The principal portion is supplied by Messrs. Firth of the Norfolk Works, Sheffield, but some tubes for the smaller natures of ordnance have been obtained from Messrs. Vickers, and Messrs. Cammell, also of Sheffield, and from Sir J. Whitworth & Co., of Manchester. The material supplied by Messrs. Firth is entirely composed of crucible steel. It is of high excellence; the rejections are but few; and, up to the present time, our experience leads us to consider it as undoubtedly the most trustworthy steel in the market, particularly when large ingots are required.

The steel supplied by Messrs. Vickers comes out particularly well under our tests, but we have not yet had sufficient experience of it to enable us to speak very positively of its uniformity. It is produced by the Siemens-Martin process.

The fluid compressed steel which forms the Whitworth speciality is of high excellence, and as a rule the castings are very sound. The qualities of the material as shown by our tests are, however, scarcely so suitable to the peculiar necessities of gun manufacture as could be wished. No doubt its percentage of elongation would be improved if it were more worked and drawn out." (1)

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(1) Note.—Colonel Maitland; On the Metallurgy and Manufacture of Modern British Ordnance. Journal of the Iron and Steel Institute for 1881, No. II.

This paper of Colonel Maitland's, Mr. Greiner, then Superintendent at the Cockerill Works, now General Manager of our leading metallurgical plant, communicated at a meeting held at Liege, Dec. 4th, 1881, and it is published in the "*Revue universelle des mines, &c.,*" of 1881, (Vol. X) under title of "The Gun Question before the Iron and Steel Institute."

We would be justified in assuming that the open-hearth steel of Vickers and of Whitworth had undergone radical improvement, as they have succeeded, after but few years, is completely supplanting crucible steel in gun manufacture, but we would be mistaken.

Paul Duteil, a French Civil Engineer, in a pamphlet, "The Metallurgy of Iron at the Universal Exposition of 1878," is of opinion that the Bessemer and open-hearth processes never yield homogeneous and uniformly dense steels.

"To obtain this," he adds, "steel must be cast in crucibles out of contact with air, so that the whole mass may be equally saturated."

Pourcel, one of the most distinguished of French steel experts, who, while in charge of the Terre-Noire Works, did so much for the open-hearth product, happily characterizes in a paper read before the Iron and Steel Institute in 1882, the esteem in which crucible steel is held by steel makers.

"Crucible steel, which still remains the *ideal* type of steel, contains less than 0.3 per cent (of silicon). (1)

We cannot close this chapter in better fashion than by quoting the most important portion of a paper on crucible steel manufacture, read in 1884, before the Chester Meeting of the Iron and Steel Institute, by Mr. Henry Seebohm, a well known maker.

"The principal reason why Bessemer and Siemens

(1) Note.—A. Pourcel. Notes on the Manufacture of Solid Steel Castings. Journal of the Iron and Steel Institute, 1882, No. II.

steel have failed so completely to supersede crucible cast-steel for purposes where the better qualities are required, is that they cannot be made sound without the addition of silicon or manganese. In melting common steel (containing, for example, from 0.15 to 0.05 per cent. of phosphorus), the steel must be poured into the mould as soon after it has become perfectly fluid as possible, and as hot as the tensile strength of the pot will allow.

In making the higher qualities of crucible cast-steel (where the percentage of phosphorus ranges from 0.01 to 0.001) a similar mode of treatment would produce very strange results, the molten steel would boil over in the mould, the fracture of the ingot when cold would show a series of bubbles like a sponge, and its specific gravity would scarcely exceed that of wood. Some of these bubbles or honeycombs would weld up when the ingot came to be forged, but by far the greater number would be coated with an oxide which would make a weld impossible, and the bar, if it was not burnt up in the fire, would be so full of the imperfections technically called "seams" or "roaks," as to be perfectly useless.

To obviate this disastrous result, it is necessary to boil the steel for nearly half an hour after it has become fluid, and then to allow it to cool down to a certain temperature before it is poured into the mould. This process is called, in the language of the votaries of the rule of thumb, "killing" the steel, and it is an axiom among them that the higher the quality of the steel, the more "killing" it takes.

It is in this part of the process of crucible cast-steel melting that its special virtue consists, and the cost and quality of the cast-steel produced depend in a large degree upon the skill brought to bear upon it. There is an old proverb in Sheffield, usually expressed in the terse vernacular of the country, but which may be re-

fined into the expression that, if you put his Satanic Majesty into the crucible, his Satanic Majesty will come out of the crucible. The converse of this is by no means the case. Though you may convert iron into steel in the crucible, you cannot convert bad steel into good steel in the crucible ; but though you may put the most angelically pure steel into the pot, you may by bad management, by not "killing" it properly, pervert it into Satanically bad ingots.

Now, this "killing" of the steel is precisely what cannot be done in the Bessemer or Siemens processes without the addition of such a large amount of manganese or silicon that the steel becomes brittle when hardened."(1)

The opinions of the eminent metallurgists and experts just cited prove, without fear of contradiction, that crucible fusion furnishes the most reliable first-quality steel, and hence, crucible steel should be insisted upon in gun construction.

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(1) Note.—Henry Seehbohm : On the Manufacture of Crucible Cast Steel. Journal of the Iron and Steel Institute for 1884, No. II.

ermature for Field Guns.

Fig. 2.

Section on

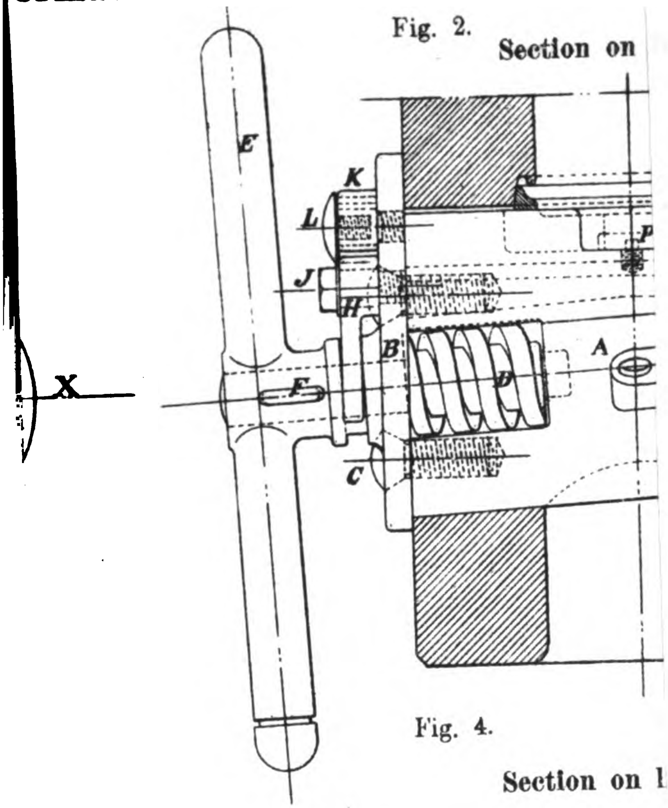
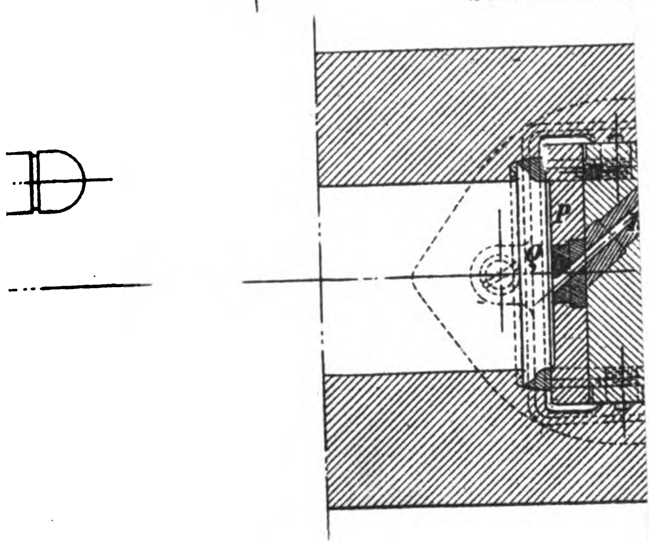


Fig. 4.

Section on



CHAPTER II.

Gun Construction.

Having settled upon a suitable metal, our next task is the selection of the strongest and best working system of construction.

At present, Ordnance officers are mainly occupied with but two types, the Krupp and the De Bange.

Krupp has designed many guns, and the limits of this little work would be far exceeded were we to attempt an exhaustive, detailed examination of each model. We must content ourselves with the general characteristics of construction, shape, fermature and gas-check. France adopted Colonel De Bange's system as early as 1878 for field-guns, and is now applying it to siege, sea-coast and naval armament. The gas-check is its novel and distinctive feature, the breech mechanism being a modified Reffye fermature, and the gun itself a close copy of its immediate predecessor, the Lahitolle. The question being thus narrowed down, let us proceed at once to examine briefly these two systems as applied to field and heavy guns.

1.—The Krupp Field-Gun.

Plate I.

A.—The Mantle.

Krupp guns are made entirely of crucible steel, an almost positive assurance, we speak advisedly, of great strength and long life. As regards construction and contour, they are built upon the model adopted in 1873;

the tube, without reinforce, is encircled by a single band or jacket, (*Mantel*, in German) shrunk on and carrying trunnions and fermature. The object of this, as of all hooping, is to substitute for the thick walls of obsolete models, thinner metal, susceptible of compression by the jacket, thus increasing its strength, and thereby obtaining *greater resistance with less weight.*

In other words, exterior and interior are both made to bear their share of the burden. As the mantle carries the closure, the tube is relieved from direct longitudinal strain, a safeguard against unbreeching.

B.—The Fermature.

1. The Breech-Slot.

The slot is a cylindro-prismatic frustum, the front wall perpendicular to the axis of the bore, the rear, slightly inclined from left to right. The upper, as well as the lower wall, carries a feather, the front edge serving as a channel, the rear, parallel to the rear face of the wedge, as a guide for its motion in and out of the slot.

A shallow half-thread, to receive the locking-screw, is tapped in the left side of the upper wall. The seat of the gas-check ring connects the slot and chamber surfaces.

2. The Breech Mechanism. (Figs. 1 and 2, 3 and 4.)

The Wedge *A*.

The wedge or breech-block fits the slot; the front face is countersunk for the gas-plate seat, and further to the right, parallel to the axis, the loading chamber *T* is cut. The right face is rounded; the left holds the locking-screw seat. Upon the upper face is a groove *Z* in which the vent-screw plays, just of sufficient length to bring the loading chamber, at the command LOAD, in

exact prolongation of the bore. A hole *R* is drilled in the wedge at an angle of 41° in a vertical plane through the axis, and counterbored at the top and bottom; the middle portion and the lower counterbore are bushed with a copper vent-plug; the upper counterbore serves as a recess for a gas-check, a copper cup of triangular cross-section, which by pressing against the foot of the vent-screw, prevents the fouling of the wedge and slot.

The Breech Cap *B* and its Screw *C*.

The breech cap guards the wedge and slot against dirt and dust, and in opening the breech, serves as a point of application for the locking-screw. It is fastened to the left face of the wedge by three screws *C* and carries the journal for the crank handle of the locking-screw. It is strengthened at this point by a circular flange, to which a stop is attached, limiting the play of the handle in opening the breech.

The Locking-Screw *D*.

The locking-screw is right-hand, and has a coarse pitch. It is supported by its shank in the wedge, and by a collar-bearing in the cap.

When the breech is closed, the screw part projects above the wedge and engages in the half thread, tapped in the slot.

To permit opening and closing the breech by a half turn of the crank, the thread, with the exception of the outside turn, is interrupted for a full semicircle.

The locking-screw answers two purposes, it imparts a transverse movement to the wedge, and forms a lock to keep the latter from sliding along the inclined wall of the slot, when the piece is fired.

THE CRANK *E* WITH ITS KEY *F* AND PIN *G*.

The crank works the breech mechanism, it consists of a collar and two cylindrical arms, the one marked by a circular groove must be, when the gun is locked, on the right of the cannoneer who serves the closure.

On the collar, as on the cap, is a stop, the two meet when the breech is closed. The collar is fixed to the screw shaft by a key *F* and a pin *G*.

THE CATCH *H* AND THE BINDING SPRING *K*.

The catch is a flat plate with an upward curved handle, roughened on the lower side to facilitate gripping. The catch can turn on the screw *I* which fastens it to the cap, but friction-tight on account of the pressure of the binding spring *K*, also attached to the cap by the screw *L*. The catch and spring prevent the accidental opening of the breech on the march, for when locked, the catch engages with the crank stop, and thus prevents its turning. In opening the breech, the catch must first be disengaged.

THE DIRT-FENDER *N* AND ITS GUIDE-STUDS *O*.

In opening the breech, the rear face of the wedge remains in contact with the wall of the slot, and hence play is allowed between the front face and the gas-check, which would permit, while loading, the entrance of dirt.

To meet this difficulty, a thin sheet brass cylinder is lightly inserted in the loading chamber. It has two studs which pass through the wedge, and enter guiding channels cut in the feathers of the breech-slot, thereby keeping the fender in contact with the gas-check when the wedge is out.

This apparent telescoping occurs both in opening and closing the breech.

THE GAS-PLATE *P*.

The gas-plate is let into the front face of the wedge, and is held by a stud which prevents its turning. It is bushed with copper at the vent entrance, and has a shallow recess cut in its front surface for receiving the powder residuum.

THE GAS-CHECK *Q*.

The gas-check ring, whose curved surface is a spherical zone, is firmly seated at the end of the gun chamber, and presses tightly against the gas-plate when the wedge is locked. Upon its plane face are cut shallow grooves to hold dirt and to restrain a possible escape of gas.

THE VENT-SCREW *W*.

This is screwed into the breech of the gun, and serves a double purpose, it closes the upper part of the vent, and controls, as already explained, the outward movement of the wedge. It has a hollow head, which serves as a hood to protect the cannoneers against powder grains and primer fragments. The middle part of the body is threaded and screwed into the breech, the lower part projects into the guide channel of the wedge, and acts as a stop.

THE HOUSING *S*.

The housing *S* of brass is shaped to the opening of the breech-slot. It is designed to receive a leather hood which keeps the breech-slot free from mud and dust.

C.—Manual of the Breech.

1. To Open.

The cannoneer first relieves the catch *H*, then seizes

with both hands the crank *E*, and turns it to the left until the stops strike ; the crank is then horizontal, with the grooved arm to the left. The wedge is then pulled out steadily until checked by the vent-screw. The loading chamber is now opposite the bore, and the piece is ready for charging.

2. To Lock.

The cannoneer pushes the wedge with both hands gently into the slot until the uninterrupted thread of the locking-screw strikes the breech ; turns the crank to the right until the cap is brought up to the piece. The catch is not let down until the command, CEASE FIRING.

D.—Gas checking.

There is no difficulty in replacing a gas-check ring.

Unscrew the vent-screw about twenty-five millimetres and take out the wedge ; thoroughly lubricate the exterior curved surface of the ring, and place it in its seat, after having carefully cleaned the latter. The correct position is fixed by hand marks on the ring and slot. The wedge, well cleaned and oiled, especially on the gas-plate, is then forced in, until the vent-screw can be screwed down, and the breech locked. As this operation requires considerable force, the handle is lengthened by slipping over one of the arms a piece of iron pipe, a part of the equipment of every gun. If the closure work too freely, insert thin brass packing under the gas-plate, until the ring is so firmly seated that it cannot be taken out by hand. After a few shots, one man can easily work the breech. It may happen, after continuous firing, that the ring is forced rather far into the bore, permitting a too free working of the fermature. This contingency is recognized by the escape of gas be-

tween plate and ring, and may be at once cured by inserting a brass packing ring under the gas-plate.

Experience has shown that, provided the pieces are in good order to begin with, this treatment will not be necessary while the combat lasts. Practice has proved that the spherical surface of the ring is never scored by gas ; erosions may appear, very rarely, upon its rear face and upon the bearing part of the gas-plate.

Should this occur during battle, no attention need be paid to it, for many rounds can be fired before the erosion extends over the whole width of the ring. However, to meet every possible demand, each piece is supplied with two spare rings and plates.

E.—Special directions in regard to the Service of the Breech.

Note the following:

Before practice,

1. That the breech cap screws are tight.

2. That the breech mechanism is clean and slightly oiled; there must be no rubbing.

3. That the vent-screw is screwed home, so that its lower face touches the copper gas-check.

4. That the vent is clear.

5. That the contact surfaces of ring and plate are not injuriously marred.

During practice :

1. That the gas checking surfaces are kept as clean as possible.

2. That the vent-screw is always home.

3. That, in every round, the locking-screw is turned until the breech cap bears against the piece.

4. If gas escape, proceed as already indicated.

11.—The Krupp Gun of large Calibre.

Plate II.

The task we undertook had chiefly to do with fiel artillery, but as we are anxious to show the unity of th Krupp system, we will briefly describe the method o breech closure adopted for heavy guns. We shall fol-low exactly the same lines when we come to th De Bange system.

A.—The Fermature.

1. The Breech-Slot. (Fig. 2.)

The slot is a cylindro-prismatic frustum; in pla trapezoid, the front side perpendicular to the axis of bore, the rear, somewhat oblique.

Circular grooves are cut in the rear wall.

2. The Breech Mechanism. (Figs. 1, 2 and 3.)

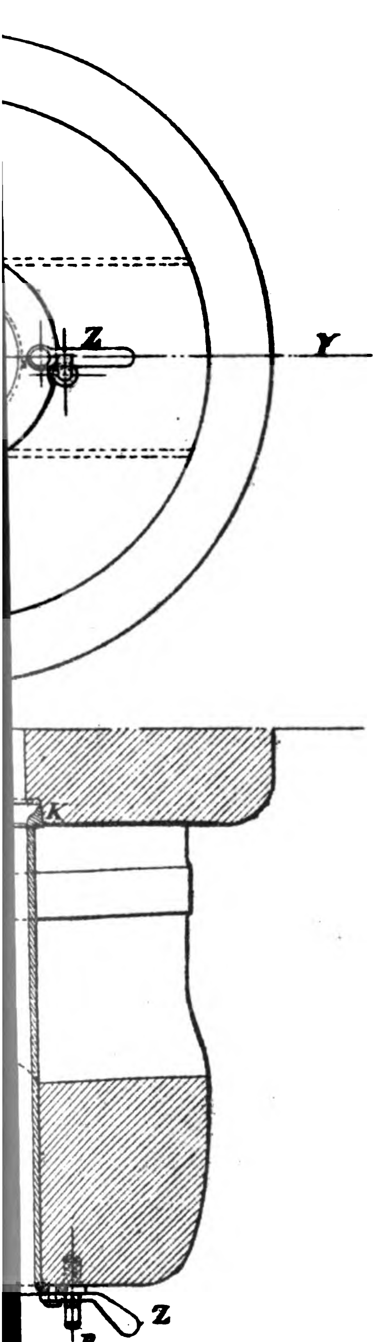
The breech-block or wedge H is cylindro-prismatic, and fits the slot, so that when pressed home it completely closes the bottom of the bore. The upper and lower faces have rectangular guiding grooves, cut parallel to the axis of the rear cylindrical surface, so that in pull-ing or pushing the wedge, its rear face is always in contact with the slot, while its front moves parallel to itself.

The wedge carries a number of seats for various ele-ments of the mechanism.

The locking device consists of a screw C and its nut B.

The neck of the screw passes snugly through the breech-cap, to which it is held by a collar and shoulder, and its foot is let into the wedge. As the thread is be-tween these two fixed bearings, there can be no transla-

Fermature for Heavy Guns.



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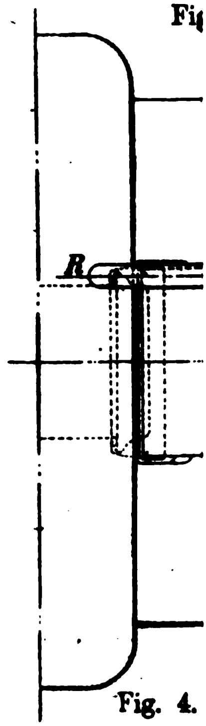
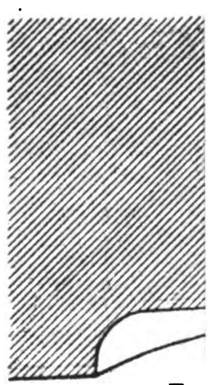


Fig. 4.
The K



Re

tion. The nut is wholly within the wedge, it is free to move slightly to and fro; a plug *x* driven into the nut next to the cap limits its rotation to one-third of a turn. The nut *B* has further several outside circular threads, the first of which is whole, the others interrupted.

To lock the breech, these threads must engage in the slot grooves; to open it, the interrupted portion must face the grooves, thus permitting the withdrawal of the wedge.

The wedge is moved by the traversing screw *D*, turning in the journal bearings *G* and *H*; and is engaged in the half nut *E*, fastened to the gun by the screw *F*.

The screws *C* and *D* are turned by the crank wrench *R*.

The gas-check is a steel ring *K*, lipped into the chamber, and seated against the gas-plate *J*. A chain, fastened to an eye-bolt in the breech and to a hook on the cap, limits the outward motion of the wedge. In loading, after the wedge is out, a charging funnel *W* is inserted in the bore; it is held in place by the handle *Z* resting on the brackets *P*, which also serve as shot-carrier supports.

B.—Manual of the Breech.

1. To Open.

Slip the crank wrench *R* over the square head of the locking-screw, and turn to the left as far as you can. The nut *B* takes up the backlash, and then turns with the screw until the plug *x* strikes the to pof the breech cap, this brings the interrupted portion of the nut opposite the slot grooves; and shows the word "OPEN," cut on its face. Its rotation being forcibly stopped, the nut must move inwards until its whole thread *M* bears against the breech.

This holds the nut tight, and as the locking-screw

keeps turning, the wedge itself moves forward until checked by the nut.

Now slip the wrench on the traversing screw *D*, turn it to the left, and the wedge comes out.

Insert the charging funnel *W* and load as usual.

The traversing screw is not a necessity, and were it omitted the fermatures of heavy and light guns would be almost identical, but the moving by hand of heavy breech-blocks would be too irksome, hence its adoption.

2. To Lock.

Withdraw the charging funnel; turn the traversing screw to the right; the wedge enters until the shoulder of the screw strikes its bearing *G*. Now turn the locking-screw *C* to the right, the nut *B* strikes the cap, and taking up the backlash, rotates with the screw until the plug *x* strikes the bottom of the cap, when the word "LOCKED" appears cut in its face; at the same time the flat portions of the circular threads engage the corresponding faces of the slot grooves, and firmly secure the wedge to its seat.

C.—The Krupp Obturating Primer.

(Fig. 4, Plate II.)

Ignition takes place at the centre of the bottom of the cartridge through the wedge, the vent being bored in prolongation of the axis of the bore.

The vent-bushing is steel; its mouth is tapped to receive the Krupp obturating primer, which insures prompt ignition, and is a certain vent gas-check.

Its parts are:

a) *A brass screw plug*, inclosing the details of the primer, keeping them in place, and protecting them from moisture and other injury.

e for Field Guns. De Bange Syst

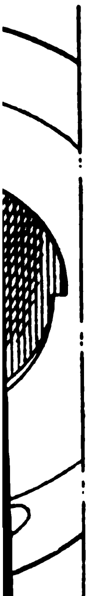


Fig. 3.

The G

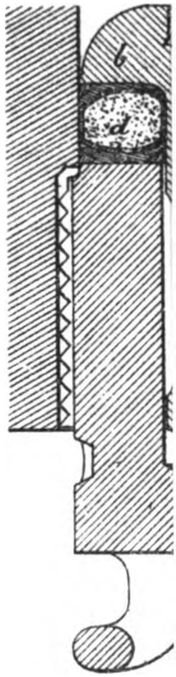


Fig. 4.

Latch *C*, heel out.

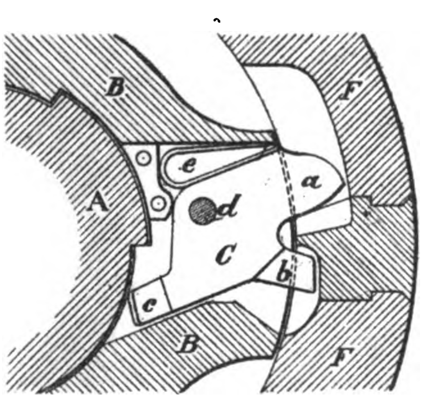


Fig.

b) *A brass friction wire*, ringed at one end for the lanyard hook, and serrated at the other, with a tapering stop just above.

c) *The fulminate*, pressed into a paper tube as in the ordinary friction primer, and surrounding the wire between the stop and the teeth.

d) *The capsule or filling*, is the same as is used in fuze plugs.

The primer is screwed tightly into the counterbored vent, and is used just like the common friction primer. Under the pull of the lanyard the tapering stop enters a corresponding countersink in the plug, and prevents the escape of gas. The screw plug itself, well greased, fits tight in its counterbore.

D.—Special Directions in regard to the Service of the Breech.

The same directions apply to the service of heavy guns that have already been given for field artillery.

In comparing the mechanism of heavy and light guns, it cannot be denied that one principle dominates all, and that the Krupp system is virtually the same for every calibre.

III.—The Reffye-De Bange Field-Gun.

(Plate III.)

A.—The Fermature.

1. The Breech-Screw Seat.

The breech-screw seat is in the breech hoop, and in prolongation of the bore; it has an interrupted thread, one-sixth being alternately planed off, corresponding of course, to similar divisions on the breech-screw. It has inserted in its face the latch-hook, an inclined rest for the upper, a catch for the lower, nose of the latch.

2. The Breech Mechanism.

THE BREECH- SCREW. A. (FIG.1.)

The screw has an interrupted thread; the gas checking device is attached to it. Its parts, beginning at the rear, are:

1. The fixed handle a;
2. The lever handle b with its pin d;
3. The lugs c;
4. The boss e;
5. The inclined guide f for the heel of the latch;
6. The chased and planed sections of the body;
7. The recess for the heel of the latch (see Fig. 5.)
8. The plastic gas-check D.

THE CARRIER-RING B. (FIG. 2).

The breech-screw is supported, when disengaged, by a hinged ring bracket, whose main parts are:

1. The hinge a with the hinge-pin b;
2. The swelling c;
3. The rest d for the cam of the lever handle;
4. The safety notch e;
5. The key with its beak f;
6. The guides g;
7. The latch c and its details.

THE LATCH C. (FIGS. 4 and 5.)

The latch is composed of:

1. The latch-bolt C and its pin d;

2. The upper nose *a* ;
3. The lower nose *b* ;
4. The heel *c* ;
5. The latch-spring *e*.

The Gas-Check *D*. (Fig. 3.)

The plastic gas-check *D* consists of ;

1. The movable spindle *a* with mushroom head *b* and shoulder *c* ;
2. The plastic packing *d* ;
3. The vent *f* ;
4. The bushing *g* ;

The packing *d*, made of asbestos and tallow, is sewed in cotton, and is supported in place by two convex tin guards. Three split brass rings close the open angles of the gas-check, and prevent the intrusion of the tin in firing, and consequent difficulty in working the apparatus.

B. Manual of the Breech.

1. To Open.

The cannoneer lifts the lever as high as he can to release it from the safety-notch, then turns it towards himself, to the left, until the lug of the breech-screw strikes the swell of the carrier-ring, at which time the threaded sections of the screw are opposite the planed sections of the seat, and the breech plug may be pulled out.

The turning has done more ; the heel of the latch has travelled up the inclined cross-guide *f*, and compelled the latch-bolt to turn on its pin, the upper nose is lifted, and the lower entered in its catch. (See Fig. 4.)

Thus the carrier-ring is freed from the screw, and secured to the face of the breech. The cannoneer now presses the lever down, the cam strikes its rest on the carrier-ring and forces the breech-screw back, loosening the gas-check from its bearing, an operation requiring some force. The plug can then be freely drawn back on its guides, until it strikes the beak of the key. During this backward motion, the heel of the latch slides along the planed section of the breech-screw until it strikes its recess, into which under the action of the latch-spring, it falls, unlatching the lower nose, and thus detaches the carrier-ring from the breech, and fastens it to the breech-screw. The plug with the ring can then be swung on the hinge, entirely exposing the seat.

2. To Lock.

The cannoneer gently swings the breech-screw against the piece forcing the upper nose of the latch to ascend its inclined rest; this compels the latch-bolt to turn, releases the heel, and allows the breech-plug to be pushed in. During this movement, the heel is forced up the inclined face of its recess, the bolt turns anew on its pin, and in pushing the breech-screw home, the lower nose enters its catch, and again the carrier-ring, free of the plug, is fastened to the breech.

The cannoneer now turns the screw to the right, the heel descends the inclined cross-guide, the bolt obeys the action of the spring, and the lower nose is unlatched; the ring is fastened to the plug, and held to the breech by the lugs and boss. If the breech is well locked, the handle falls of its own weight.

C.—Directions in case of trouble.

With the breech. 1. Should No. 2 find it hard to

open the breech by hand, No. 1 taps the lever pin with the trail handspike, handed to him at once by No. 3.

The breech being open, No. 2 scrapes with a knife and washes with a sponge the gas-check head, makes certain that it turns freely, and tries to lock.

Should there be further difficulty, he reports to the Chief of piece.

2. Should the latch-spring break while the breech is unlocked, No. 3 draws back the plug, and lifts the heel of the latch by pressing upon the upper nose with the fore-finger of the right hand.

He gets rid of the fragments of spring, and replaces it.

The breech can be worked without a spring, by unlatching by hand.

3. Should a primer split and stick, No. 2 clears the vent with a gunner's gimlet.

4. In case of any other accident to the closure or gas-check, No. 2 at once reports to the Chief of piece, who either proceeds as indicated in Part II, or asks the Chief of section for further instructions.

We have thus explained the course to be pursued in case of certain accidents that may happen during firing, but there are other drawbacks possible which must be met, and their recurrence prevented.

Battery repairs should be made with the utmost care, and always under the supervision of an officer.

With the gas-check.—To insure the perfect working of the gas-check, the spindle must drop easily into its place as far as the fillet and turn freely. Every time a new gas-check is used, this must be ascertained. Should there be difficulty in inserting, it may be due to rough edges on the spindle seat, or to its having been closed by the upsetting of the vent plug ; in one case,

use a file, in the other, replace the plug, or ream it out. When a new gas-check is inserted, to prevent the destruction of the rear tin guard on the first round, the head must be tapped with the rammer to settle it in place.

It may happen that during the firing the cloth cover is torn, and the packing exposed. This is of very little moment, and no attention need be paid to it.

Should the front guard begin to fuse, which indicates imperfect gas checking, it is very probably caused by by the spindle's fitting too tightly; the remedy has already been pointed out.

The brass rings may open, and thus impede the movement of the breech-screw; this difficulty is overcome by simply closing them again.

When the breech is open, should the head of the spindle receive a blow, the packing, especially if heated and softened by firing, may be crushed and distended; this distortion may also occur, if it be very soft, on roughly opening the breech. Usually this may be remedied by kneading the pad into a cylindrical shape, so as to be able to close the breech. The packing may be cooled and hardened by plunging it in water, or wetting it with a sponge, and it may be moulded in its seat by tamping with a ramrod.

With the breech-screw.—Slight abrasions, interfering with the free movement of the plug may be filed down; roughnesses on the screw should be ground off by working it in its seat with very fine emery flour and oil.

With the gas-check spindle.—The spindle shank may be upset; if it do not exceed two or three millimetres and remain stationary, it may be neglected, otherwise substitute a new spindle.

With the vent.—Should enlargement cause missfires,

ns of large Calibre. De Bange Sy

Fig. 3.

The De Bange dou
(The taper is in

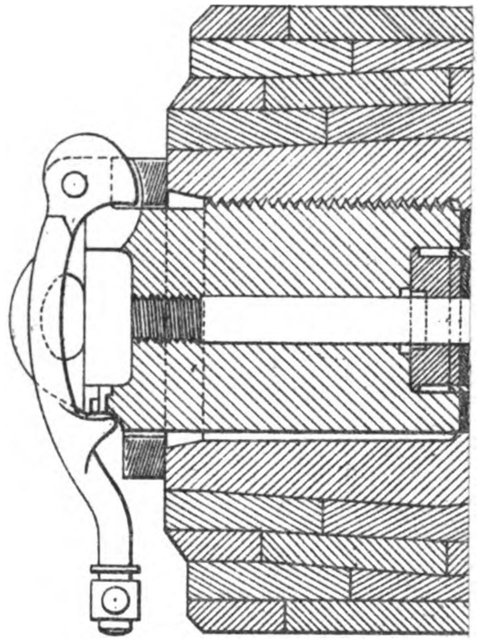
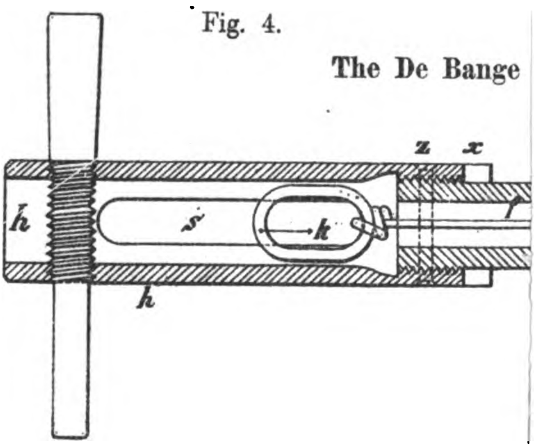


Fig. 4.

The De Bange



replace the spindles in guns of eighty and ninety millimetres calibre, and renew the bushing in those of ninety-five millimetres.

NOTE.—*The spindle or packing should always be renewed under the supervision of an Officer.*

IV. THE REFFYE-DE BANGE GUN OF LARGE CALIBRE.

(Plate IV.)

We cannot do better, in explaining Colonel De Bange's system for heavy guns, than to describe the main features of the thirty-four centimetre gun exhibited last year at Antwerp.

A—The Double-taper Hooping. (Fig. 3.)

The thirty-four centimetre gun is built up of a hammered steel tube and seventy-four steel hoops.

The first row of hoops extends over the whole length of the piece; the second, from the breech to the middle of the chase; the third, from the rear face to in front of the trunnions, the fourth is made up of the three breech coils and the trunnion ring.

The double-taper adopted for the gun is designed to make all the hoops share in bearing longitudinal strains. Usually the hoops resist, so to speak, only tangential strains, as the tube and rings are bound together by shrinkage-friction alone.

But, owing to the difficulties of construction, the shrinkage strains may vary at points, or even entirely disappear, and even were they at all points as great as desired, yet the resulting cohesion is not sufficient to prevent unbreeching.

It must be understood that this is the theory of the inventor, we shall discuss it later.

According to Colonel De Bange, the double-taper over-

comes this defect, and profitably supersedes complicated methods of banding followed by others. It consists simply in making the outside of the tube and rings, a series of truncated cones alternately with their smaller or larger bases in contact, so that by superposition the whole is firmly anchored together. The taper is so slight that the hoops, when heated, can be slipped on the tube and over each other, and yet sufficient to insure upon cooling a powerful bond. The hoops are coiled of steel bars, rolled and welded. Captain A. Mariotti in his phamplet, " French and German Guns," in speaking of this method, says :

" Even should a flaw exist and remain undetected before rolling, hardly conceivable, it could not extend beyond its own coil, and would not affect the other strands that make up the hoop."

According to this author, Colonel De Bange believes that, thanks to his system, guns can be made lighter and stronger than by other methods.

We shall examine the system critically in the next chapter.

B.—Breech Mechanism and Gas-Check.

(Figs. 1 and 2).

The breech-screw is interrupted, supported by a carrier-ring, and while very much larger than in the field-guns, is practically similar in construction. There is a gas checking device made up as follows :

The breech-screw *A* is drilled and partially tapped for the vent-piece *B*, the collar *P*, of which rests upon a counterbore, cut into the bottom of the screw as a seat for the plug *C*.

This plug is held to the collar *P*, and to the face of the counterbore, by the hooks *S* passing through the notches *R* and fastened in the slots *T*. Between the

tenon of the plug *C* and the counterbore, a space is left in which plays the hollow stem of the free gas-check head *E*. The double packing *D* is held between the plug and the head. A washer *F* is pinned to the vent-piece *B*, and firmly unites it, the breech-screw *A* and the plug *C*. The gas-check head and the packing can turn on the vent bushing stem ; they have also some play lengthwise on the plug tenon, which permits a backward movement, under the pressure of the gas on firing the gun. The hollow stem *L* separates the packings, composed of the same elements as already described, asbestos and tallow covered with cotton cloth and protected by tin guards ; as before, the connecting angles are shielded by split brass rings.

The stem has holes *M* drilled in it, which are filled with the composition, so as to keep the two packing rings duly balanced.

In firing, the outer packing presses against the chamber, the inner against the vent piece, thus effectually cutting off all escape of gas, so the inventor claims, as the pressure of the rings per unit of section exceeds the gas pressure, their surface being less than that of the gas-check head.

C.—The De Bange Obturating Primer.

(Fig. 4.)

The De Bange primer consists of :

1. The *case*, *a ;*
2. The *free spindle*, *b*, set in the case ;
3. The *wire*, *c*, passing through the spindle *b ;*
4. The *spindle stem*, *d ;*
5. The *plastic packing*, *e*, surrounding the stem *d ;*

6. The *head*, *f*, in which the stem *d* can move, but backward only ;

The head *f* is chased with a couple of coarse interrupted threads, allowing it to work in the vent, just as the breech-screw does in its seat. Upon the head is screwed a hollow wrench with a large opening, opposite which is the ring *K*, fastened to the friction wire. Upon firing, the free spindle *b* compresses the packing, thus shutting off the escape of gas by the vent; the wire *c* closes its own passage, thanks to a conical stop which it carries.

The wire is pulled by means of a bell-crank *rq*, (Fig. 2) one of whose arms carries a hook for the ring of the wire, the other is attached at the proper time, to the lanyard.

V.—Comparison of the two Systems.

The De Bange field-gun is as a rule made of Open-hearth steel.

French ordnance officers care very little by what process the steel delivered at the Arsenals is produced; their idea is that all steel is suitable for *gun-metal*, provided it fulfills the required specifications.

Still, it cannot be questioned that most, if not all the steel furnished is made by the Martin-Siemens process.

We have already given the reasons for preferring Crucible steel, and need not iterate them.

In carefully comparing the two breech mechanisms, just briefly described, though it might strike one that the French fermature is a more logical development, as it works in the *direction of the axis*, yet actually it is much more complicated than the German.

The Krupp closure is virtually a block, working *perpendicularly to the axis*, and cannot therefore be blown

cut, in case of imperfect locking. The wedge bears, not against the body of the gun, as was the case in older models, but against a mantle shrunk on the gun, thus permitting the tube to offer its maximum resistance. The number of parts forming the breech mechanism may be summed up in the wedge and its locking screw. The system is extremely simple, its operation rapid and easy, and for these very reasons, no fears are aroused as to its strength or working under fire.

On the other hand, the French fermature depends upon screw threads, which receive the full force of the discharge.

These engage in female threads cut in the tube, and extended experience has proved that these latter soon give evidence of stripping and cutting.

It has occurred frequently in the bursting of guns that the surface of rupture passed through one or other of these threads, although neither fermature nor gas-check was injured, showing conclusively, to use the graphic words of Lieut. Colonel De la Rocque of the French Marine Artillery, that these threads are *actual bait to attract rupture.*

The work of this officer of rank, "Historical Study of the Strength of Rifled Guns," gives in regard to this matter some rather interesting facts.

He states that an Ordnance Board convened at the Ruelle Gun Foundry to investigate the unbreeching of a 34 centimetre gun, made of Open-hearth steel supplied by the Saint-Chamond Works, a casualty that occurred January 22, 1880, at the third round with a charge of 112 kilogrammes, reported that *the surface of rupture passed through the first thread of the three sections.*

Another 34 centimetre gun, also of Saint-Chamond steel, was spiked with a charge of 126 kilogrammes on account of the *stripping of the threads.*

"The screw," says our author, "had cut, so to speak, into the metal of its seat."

Other guns made of Creusot steel with the same fermature, stood the test better. "But, adds Colonel De la Rocque, "the female threads of all these guns were injured more or less during the firing ; the screw's cutting into the comparatively soft metal of the piece caused harrassing delays and difficulties." The Board appointed to report upon these accidents and mishaps used the following language : "The cause of the accident lies in the bad quality of the steel, which, as shown by results from test bars, was especially poor near the rupture line and in the interior of the tube, while at the ends and on the surface, *where alone it could be examined and tested* before the failure, it was of good quality." Indeed, we emphasize that specimens cut here and there from a hammered block and physically tested, do not offer a sufficient guarantee as to the good quality of the metal, when homogeneity is not a direct result of the process of manufacture.

An *absolute* homogeneity is attained, not from the Martin-Siemens furnace, but from the crucible alone. The Board, in view of the fact that *a local defect in the vicinity of the thread nearest the bottom of the bore* can bring about such accidents when the breech-screw is seated in the tube itself, submitted a plan for seating it in a base ring, as had already been done in other calibres. It further proposed an increasing pitch, quick enough "to make the furthest threads bear first," or in other words, to ease up on the nearest, and thus husband their strength.

These conclusions evidently imply that the closure, with screw-plug seated in the body of the gun, is not satisfactory ; the changes recommended by the Ruelle Board, which have been adopted, mitigate but do not cure the inherent defects of the system, the liability of

the threads to injury, and the possibility of unbreeching by the wrenching of the tube under the effort of the gas to escape by the threads. Of course, these possibilities are enhanced if the metal is not homogeneous.

Mr. A. Grenier, at present Manager of the Cockerill Steel Works, in a paper on the French and German Breech Systems read some years ago before the Society of Engineers of Liége, wrote as follows: "France and, following its example, Sweden have adopted closure by means of a steel screw. The threads are interrupted, so that a fraction of a turn locks the breech. This appears simple, but experience has shown that it is not effective.

It is almost impossible to obtain perfect contact between the screw and nut; notwithstanding prolonged emery grinding, the threads will vary, and the shock will effect some more than others.

Most breech-screws soon show injuries to the threads nearest the charge, which render them unserviceable."

These remarks have value and interest now, they accord perfectly with our views.

As regards the service of the piece, it is plain that the wedge is superior to the screw; to instance, the French gun can not be aimed until the breech is closed, the German, as soon as the charge is inserted.

In working the fermature in high angle firing, the screw tends to slip out, a rather uncomfortable attribute.

We come now to the methods of gas checking. We think it a difficult task to find a simpler, a surer, a lighter gas-check than the Broadwell ring. That the De Bange gas-check perhaps works well in the beginning, we will freely acknowledge, but the asbestos packing will not long keep its moulding quality, so remarkable at first, and, once unserviceable, it is harder to replace than the Broadwell ring, it takes a long time, and being rather a nice operation, the presence of an

officer is necessary. No especial precautions are required for the insertion of a Broadwell ring; it is a very simple thing to do. The French regulations governing the service of the De Bange field-guns, show better than we can, the incessant care required in the working of the plastic gas-check.

The extracts we have already given, will excuse our making further quotation.

This device, under intelligent supervision, will work well on the *practice* ground, but on the *field of battle*, amid a thousand distractions, under the impulsive action of excited men, it will soon become unserviceable.

CHAPTER III.

Ballistic Performance.

The ballistic examination of the two systems, in other words, the comparison of the respective energies, initial velocities, ranges, and accuracy, will determine which of the two, Krupp or De Bange, has gotten most out of metal and powder. We shall confine ourselves to the consideration of these four factors, though there are also to be thought of, selection of powder, construction of projectiles, and many others.

It is impossible to place in juxtaposition every detail of the two systems; here too, we must be content with a comparison of characteristics.

Moreover, this comparison, as our readers will observe, can not be exhaustive, as the calibres are not exactly correspondent but, even with all these restrictions, it will deal with sufficient data to make it conclusive.

In making a comparison of this nature we must confine ourselves to existing models, to results upon which range tables are based, to targets as given in actual practice. So far as regards proposed models, there is often so wide a difference between the promises of the projectors and actual performance, that they can not be considered as governing elements in an investigation of this nature. Deviation from this rule, under exceptional circumstances, is brought especially to the reader's attention. One further remark. The De Bange guns made at the Cail Works, are of standard model, hence we have taken our data from the French range tables,

as alone reliable; those given by the Works being founded upon no trustworthy tests. The Krupp data are founded for the most part upon tables, drawn up from the results of trials made at Meppen *in the presence of officers of all nationalities.*

Let us now proceed to consider the main subdivisions that make up artillery armament.

I.—Mountain Guns.

The De Bange mountain gun, calibre 8 centimetres, has an initial velocity of 257 metres, and, with 24° elevation, the maximum permitted by the carriage, a range of 3752 metres. Colonel De Bange, it is true, claims for this piece a range of 5,000 metres, but this cannot be attained even if the trail be sunk into the ground until the elevations reaches 45 degrees.

Krupp fabricates several models of mountain guns, varying with the topography of the countries for which they are designed.

His 7.5 centimetre gun approximates most closely to the 8 centimetre French, we will compare these two.

The charge is the same for both guns, 0.4 kilogram. The French projectile is the same as used for field-guns, its weight, 5.6 kilogram, is considerably greater than that of the special German projectile, 4.3 kilogram. Hence the initial velocity of the Krupp gun is much greater, 294 metres.

The *excessive* weight of the French projectile reduces the number carried by each pack animal, a very important consideration, and, as a result of the low initial velocity, the shock of the recoil is harder on the carriage, which is therefore more strongly constructed than the German, and is, of course, much heavier.

It is well known that the useful effect of a gun, so far as regards actual performance, is measured by the

ratio of total energy to the total weight of gun and carriage.

The De Bange ratio is 68.5 kilogram-metres, the Krupp, 74.

We can then assert, with justice, that Krupp has gotten more out of his metal and powder than De Bange has.

As regards accuracy, the French mountain gun at 3100 metres has a longitudinal deviation of 14 metres, a horizontal deviation of 7 metres; at the same range, the figures for the German gun are 19.8 and 2.3 metres respectively.

II. Field-Guns.

The French 8.9 and 9.5 centimetre guns were adopted subsequent to the present 7.8 and 8.8 centimetre guns of the Prussian artillery, which were introduced in 1873. This evidently accounts for the attempt made by the French ordnance officers to render their guns more efficient.

Have they succeeded ? That is the question.

We must state, right here, that during the past few years Krupp has fabricated four new models of 7.5, 8.4, 8.7 and 9.6 centimetres respectively, and that at present still further improved guns are undergoing trial at Meppen.

At first sight, it is rather astonishing that Krupp should have provided so many calibres, but, supplying as he does, numerous governments, whose circumstances of terrain, a most important factor in the equipment of Field artillery, differ, he was compelled to design suitable models. Indeed, this continued embodiment of ballistic conditions, these trials carried on on so great a scale, give indubitable proof of the exhaustive grasp and technical skill of the steel-maker of Essen.

The weight of the 8 centimetre De Bange gun and carriage is nearly the same as that of the 8.8 centimetre Krupp, model of 1873; the muzzle energies are about equal; it follows then that these French guns can at most be placed on a level with the older German guns.

But Krupp has recently produced models of far greater power, which must of course be superior to the present De Bange guns.

With such extensive material at command, we have selected as units of comparison, guns of about the same calibre and weight, and have collected the principal data in accompanying table. A careful examination will lead to a fair judgement regarding the respective values of the two systems.

FIELD GUNS.

		FRENCH.			KRUPP.				
		De Bange.		DeLahitolle	Model 1873.		Model 1880.		
		8 cent.	9 cent.	9.5 cent.	8 cent.	8.8 cent.	8.4 cent.	8.7 cent.	9.6 cent.
Weight of gun	Kilograms	425	530	706	390	450	450	450	625
Weight of gun and carriage . .	"	955	1,210	1,450	893	985	980	980	1,195
Weight of shell .	"	5 6	7.95	10.95	5.09	7.02	7.0	6 8	12
Weight of charge	"	1 5	1.9	2.1	1 25	1.5	1 5	1 5	2.6
Initial velocity	Metres.	490	455	443	465	444	459	465	435
Muzzle energy	Metre-tons.	68.5	84	109 5	56 2	70 5	75	75	116
Energy per kilog. of gun .	Kilog.-metres.	161	158	155	144	157	167	167	185
Energy per kilogram of gun and carriage	"	72	70	75	63	71 5	76	70	97
Number of rounds carried per piece . .		29	27	—	39	33	33	33	22
Range at 25° elevation.									
According to Krupp's tables.	Metres	6,550	6,600	7,080	5,900	6,000	6,470	6,530	7,245
According to the French tables.	"	6,990	6,890	6,550					

The superiority of one gun over another lies, we repeat it here, not so much in the initial velocity as in the muzzle energy.

With a light projectile it is an easy matter to obtain high velocity, but in the same calibre, the relatively heavy projectile with medium velocity conserves its energy at long range much better than the light projectile with the higher velocity. Hence, in most cases the former is more advantageous. Krupp has chosen wisely in adopting the heavier projectile.

Two points must be borne in mind :

1. The same gun with the same charge develops sensibly the same muzzle energy, whether the projectile be heavy or light.

2. The useful effect of a projectile is measured by the terminal energy.

From this, it is readily seen that the useful effect of the Krupp guns is greater than that of the De Bange. This superiority is more clearly evident if we call to mind that the 8.8, 8.4, and 8.7 centimetre Krupp guns are provided with two carriage seats, the subtraction of whose weight, 35 kilograms, would show a marked increase in the ratio of effect.

Notwithstanding their greater weight, more rounds are carried with the Krupp guns, another circumstance in their favor.

As regards accuracy, another factor of comparison, the following table of probable deviations of similar pieces at a range of 2,000 metres shows that in this respect also, the Krupp excel the De Bange guns.

PROBABLE DEVIATIONS AT A RANGE 2,000 METRES.							
FRENCH GUNS.	Longitudinal.	Vertical.	Horizontal.	KRUPP GUNS.	Longitudinal.	Vertical	Horizontal.
Cent.		Metres.	Metres.	Cent.		Metres.	Metres.
8	"	0.7	0.7	8.4	"	0.55	0.54
9	"	0.8	0.7	8.7	"	0.6	0.6
9.5	"	0.9	1.1	9.6	"	0.6	0.45

III. Siege Guns and Guns of Position.

There are two classes:

A. Long guns;
B. Short guns.

A. In the first class are the De Bange 12 and 15.5 cent.; the 22 cent. is still under trial.

The French 12 cent. gun is similar in most particulars, especially in weight, to the Krupp 10.5 cent. and the light 12 cent. gun, tested at Meppen in 1880, *whose power however has since been greatly increased by modifications of charge and powder.*

The 15.5 cent. De Bange gun is somewhat lighter than the 15 cent. Krupp. But this advantage, possessed by all the French pieces, is but apparent, for if we take into consideration the *total weight* of gun and carriage, we find that the French is heavier than the German.

The 15.5 cent. gun furnishes a striking example, for while it weighs 470 kilograms less than its German rival, its carriage weighs *almost double,* so that the total weight of gun and carriage in one case is 5,800 kilograms, in the other, 4,760.

Of course we must not lose sight of the fact that

while lightness is a precious quality, indispensable in field artillery, it is not wise to go to extremes, for *the lighter the gun, the greater the effect of recoil upon the carriage.* A light gun requires a proportionally much heavier carriage, and virtually nothing is gained.

The minimum weight of a gun may be determined, as a rule, by assigning such weight to the carriage as may be *necessary* for its acknowledged work, to the gun, such weight as may be *admissible*, keeping in mind the total and the requirements of mobility. Hence, in equipping a siege park, preference will be given to comparatively heavy pieces. These remarks are almost axiomatic, and it seems puerile to iterate them here, yet, notwithstanding their apparent simplicity, there is considerable variance of opinion in their application. For example, Germany has decided in favor of the heavy gun and light carriage, France, just the opposite, and yet both countries possess an equal number of distinguished Ordnance officers! The initial velocities of corresponding guns of the two systems vary within rather narrow limits, easily explained, as the weights of charge and projectile are about the same. At first sight then it would appear that the lighter De Bange gun is more effective, but when we compare as *ratios of effect*, the total energies divided by the total weights of gun and carriage, we find that the Krupp guns exceed the De Bange by from 16 to 30 *per centum*.

The following table proves this :

LONG SIEGE GUNS.

		DE BANGE.		KRUPP.		
		12 cent.	15.5 cent.	10.5 cent.	12 cent. light (1.)	15 cent. (2.)
Weight of gun	Kilograms.	1,200	2,530	1,175	1,120	3,000
Weight of shell	"	18.3	40	18	18	31.5 / 39.
Weight of charge	"	4.5	8.75	4.7	4.5	9
Initial velocity	Metres.	484	460	485	475	520 (3) / 480 (4)
Weight of carriage and gun	Kilograms.	2,654	5,800	2,275	2,200	4,760
Energy per kilogram of gun and carriage	Kilogram-metres,	82	74	95	94	96
Range at 30° elevation	Metres.	8,700	9,160	8,960	7,900	9.560

(1.) In addition to the 12 cent. light gun, Krupp has, among his long siege models, a 12 cent. heavy gun, weighing 1,425 kilograms, firing 16.4 and 20 kilogram shells with a charge of 4.5 kilograms, giving initial velocities of 520 and 480 metres respectively.

(2.) This gun, like the 12 cent. heavy, uses two projectiles, and has, consequently, two initial velocities.

(3.) Ordinary shell.

(4.) Hardened steel battering shell.

As regards accuracy, the French 12 cent. gun at 7,400 metres has a rectangle of probable deviation 18 metres long, 4.7 wide; the Krupp light 12 cent. gun, the result of actual trial, a rectangle 17 by 2.9.

At 9,600 metres the De Bange 15.5 cent. gun has a rectangle 45 to 26, and the Krupp 15 cent. a rectangle 21.2 by 8.2.

B.—As regards *short guns*, the De Bange construction is represented by the short 15.5 cent. gun, the 22 cent. and the 27 cent. mortar of the same calibres as the standard French models, although varying in ballistic data.

It is claimed that the De Bange guns are superior to the service.

We honestly wish that the French designer may meet with success in his constructions, but thus far, we must state, the improvements are still but glowing promises. The Works engaged upon De Bange guns have not as yet turned out a single piece that, *under trial*, has come up to the announced results, and not a gun of these types has been delivered to any Power. For comparison then, we must as stated, confine ourselves to *service* De Bange guns, until the claims of the makers are confirmed by authentic *journals of firing*. The data cited apply to the standard French models, as given in the regulation tables.

The following table compares these guns with the corresponding Krupp. It will be observed that the pieces bear different names in the two systems, but "*short gun*," "howitzer," "mortar," concerning which there is no general agreement, may here be deemed synonymous, in so far as the names are applied to guns of about equal weight, length aud energy. We see that the French short 15.5 cent. gun about corresponds to the Krupp 15 cent. howitzer, the French 22 cent. mortar comes between the Krupp 21 cent. mortar and howitzer, and the French 27 cent. mortar is very nearly the same as the Krupp 26 cent. howitzer.

SHORT SIEGE GUNS.

		DE BANGE.			KRUPP.			
		Short 15.5 cent. Gun.	22 cent. Mortar.	27 cent. Mortar.	15 cent. Howitzer.	21 cent. Mortar.	21 cent. Howitzer.	26 cent. Howitzer.
Weight of gun . . .	Kilograms.	1,025	2,130	5,750	1,120	1,130	3,030	5,800
Weight of shell	"	40	98	170	31.5	91	91	174
Weight of charge . . .	"	2.8	6.35	15	2.5	3.6	7.25	14.5
Initial velocity	Metres.	291	260	290	300	200	300	300
Weight of gun and carriage .	Kilograms.	2,474	4,300	11,500	2,220	2,080	5,030	11,000
Energy per kilogram of gun and carriage . . .	Kilog.-metres.	70	79	63	65	80	83	73
Maximum ranges	Metres.	6,400	5,200	5,200	6,740	3,570	7,260	7,500

It is clear that the Krupp pieces are more effective than the French.

It may not be entirely devoid of interest to compare a Krupp gun with a new De Bange, on the supposition that the latter exists otherwise than on paper, that it has been actually constructed and possesses the ballistic qualities assigned to it in the self-laudatory prospectus. We will take for this purpose the De Bange 27 cent. mortar and the Krupp 26 cent. howitzer. The following table exhibits their main particulars:

	27 Centimetre De Bange Mortar.	26 Centimetre Krupp Howitzer.
Weight of gun . . . . Kilograms.	5,700 (1)	5,800
Weight of shell . . . . "	180	174
Weight of charge . . . . "	16	14.5
Initial velocity . . . . . Metres.	300	300
Weight of gun and carriage, Kilograms.	11,500	11,000
Energy per kilogram of gun and carriage . . Kilog.-metres.	72	73
Maximum Range . . . . Metres.	8,000	7,500

(1) These particulars are given by the Cail Works of which Colonel De Bange is the General Manager.

It is very evident that pains were taken in designing the mortar, a later creation, to follow closely the Krupp howitzer.

Notwithstanding this, the French piece, *which has neither been constructed* nor, necessarily, *tried*, is not quite as effective as its German prototype.

The makers claim for it a range of 8000 metres, while

the howitzer has but 7500. Now, as the density of section (weight per square centimetre) of the De Bange 27 cent. projectile is somewhat less than that of the 26 cent. Krupp, it follows, both having the same initial velocity, that the range of the former cannot be greater than that of the latter. The range given, 8000 metres, is as supposititious as the gun itself.

Even should the 27 cent. De Bange mortar become a reality, it will at best *only equal* the Krupp 26 cent. howitzer, *constructed and tested long before.*

The short French pieces are designed to function both as howitzers and mortars; they are mounted on slide carriages, whose working is not altogether what it ought to be. Krupp, recognizing that if too many duties be imposed upon a gun it may fail to perform any one of them satisfactorily, makes therefore two distinct classes, howitzers and mortars.

The Krupp 15 and 21 cent. howitzers are mounted on siege carriages, the larger ones on casemate carriages with hydraulic buffers. The mortars are mounted on specially constructed recoil-less carriages. All these carriages have been tried and the results published in the well known Krupp Reports of the practice at Meppen.

Many of the various guns have been furnished to foreign governments, an undeniable proof of appreciation.

To complete the comparison of these short guns, one last factor is missing, accuracy, but we had no data at command. Still we need not fear to assume from the results at Meppen and on other proving grounds, that the short guns are as effective for their kind as the other Krupp designs.

IV.—Sea-coast and Naval Guns.

We have now reached the last division of our comparison, and are somewhat embarrassed, as one of the

competitors appears to be altogether wanting. Indeed the only heavy De Bange guns concerning which there exist absolute data are the French service cast-iron rifles, steel lined and banded, of 19 and 24 cent. calibre.

The 24 cent. gun weighs 16,200 kilograms, and with 28 kilograms of powder gives to its 120 kilogram projectile an initial velocity of 470 metres. Certainly there is little use in comparing such a weapon with modern high-power Krupp guns. Besides the cast-iron piece, the official list also names among service models a 24 cent. steel De Bange gun, which weighing about 14,000 kilograms, is to fire a 153 kilogram projectile with a 38 kilogram charge.

Unfortunately, we are ignorant of the velocity imparted, and hence cannot judge the gun's merits.

The prospectus of the Cail Works indeed, describes two types of steel 24 cent. De Bange guns, to wit:

1. One weighing 14,000 kilograms, firing a 155 kilogram shell with a charge of 50 kilograms, and giving an estimated initial velocity of 550 metres:

2. Another longer, of 17,000 kilograms weight, a 155 kilogram projectile, 60 kilogram charge, and 620 metres velocity.

Are these guns constructed, or merely planned? We cannot answer.

We must further add the 34 cent. gun exhibited at Antwerp, weighing 37,500 kilograms, and firing, still according to the statements of its designer, a 400 kilogram projectile with a 180 kilogram charge and 600 meters initial velocity.(1)

Up to the present time, not one of these guns, we can so assert without fear of contradiction, has fired a single shot under the specified conditions. Were it otherwise, we may rest assured the details of the tests would have

(1) For particulars concerning the trial of this gun see appendix.

been gladly published by those interested. We do not cite the newspaper reports of the trial at Calais of the 34 cent. gun, before forming an opinion, we prefer awaiting the detailed report of the "Revue d' artillerie," a technical journal of recognized worth and impartiality. Further, we may be sure that not one of these models has been adopted by a foreign power, for were it so, the conditions to be fulfilled for service would of necessity be fixed and known.

We must also point out that in studying Krupp high-power ordnance, the present German naval guns must not be taken as a proper criterion, for that would be following in the wake of those military writers who compare the Krupp and De Bange field pieces, by taking as a standard the Prussian guns of 1873, entirely ignoring the fact that since that time they have been made much more efficient.

The German naval armament dates back to the first epoch of steel guns ; it has been remodelled, so far as practicable, to meet the demands of the present. We deem that this capability of being, so to speak, rejuvenated without great expense, is an additional striking advantage possessed by the Krupp system. Still no competent judge would dream of demanding extraordinary ballistic qualities from such converted material.

A rumor has spread that the German navy distrusts the new Krupp cannon. Numerous trials conducted at the Meppen proving ground, amongst them those with four 40 cent. 120 ton guns, 35 calibres long, made for Italy, have demonstrated the perfect and, so to speak, unique attributes of the Krupp construction, even of the largest calibres. Most of the powers have given up the fabrication of heavy ordnance, and place their orders at Essen, and the leading purchaser is Germany !

Although we cannot, as already explained, compare Krupp and De Bange guns of large calibre, yet the data

given by Lieutenant Colonel De la Rocque will enable us to understand the efforts made in France to compete with Krupp.

The following compilation is instructive :

	Guns of the French Marine Artillery.			KRUPP GUNS.—MODEL 1880.											
				30 Calibres long.						35 Calibres long.					
Calibre . . . Cent.	27	34	42	24	26	28	30.5	35.5	40	24	26	28	30.5	35.5	40
Weight of shell . Kilo.	216	420	780	215	275	345	455	725	1050	215	275	345	455	725	1050
Initial velocity. Metres	540	510	530	505	505	505	505	505	505	530	530	530	530	530	530

We may fairly ask, has the French Marine Artillery yet reached the goal towards which it is striving ? According to De la Rocque himself, mishaps occurred during the proof of the first steel 27 and 34 cent. guns, and but *lately the first two 42 cent. guns broke in the chase* during proof at La Ruelle. Contrast this exhibition of incapacity with the fact that the Essen Works, for at *least five years past, have furnished as regular stock* all the calibres mentioned above.

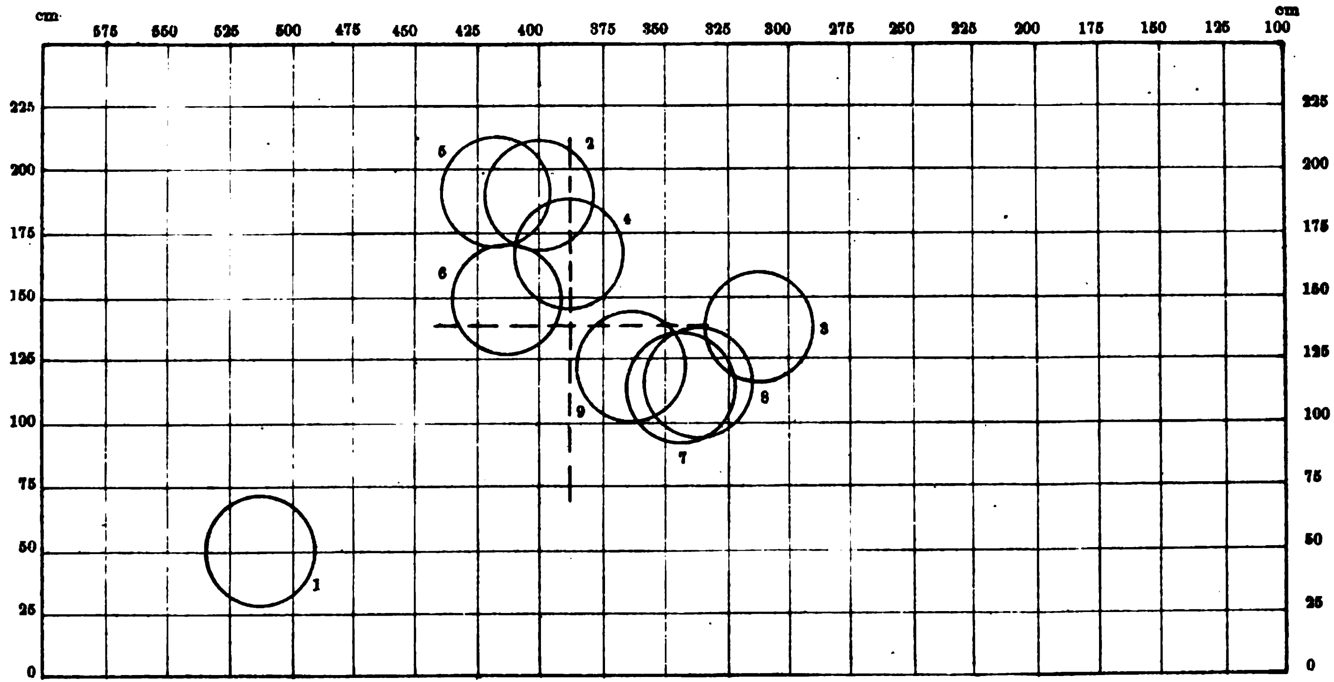
This argument *ad hominem* admits of no reply, and requires no commentary. We need not dwell upon the wonderful accuracy of the Krupp high-power ordnance, it is too well known. We do not, however, go so far as does the circular of the Cail Works, with regard to the 24 cent. De Bange, and claim that the Krupp gun will hit, at every round, a vessel of war, 1,200 metres distant ! ! !

Respect for our technical readers, and faith in the good sense of those not up in ballistics, forbid our indulging in such a jest. We are content, in answer to this claim, to present on plate V, the target of nine

40 cent. Krupp Target

fired at the Meppen Proving Ground, March 18th, 1886.

Number of rounds 9.



rounds, fired at Meppen, March 18, 1886, from the 40 cent. gun, at 2,500 metres range. The shell weighed 920 kilograms, the charge 330, giving a mean velocity 125 metres from the muzzle, measured by the Le Boulengé Chronograph, of 553 metres.

CHAPTER IV.

The Krupp System in European States.

We believe that it may prove of interest to pass rapidly in review the armament of the principal European States.

I.—England.

England was the last country to adopt breech-loading. She obstinately adhered in this, as in other branches of military art, to obsolete ideas, and still apparently suffers from the consequences of this policy, as shown by Mr. Anderson's remarks at a recent meeting of the United Service Institution, where he uttered these emphatic words:

"At the present moment, unfortunately, our Ordnance Department is not in a condition to issue designs upon which manufacturers would be inclined to stake their money and their reputation."

England has finally abandoned, in theory at least, her system of gun construction, based on steel tubes banded with wrought iron coils, and has adopted guns made entirely of steel. Woolwich and Elswick have been, or are being, converted into heavy steel gun factories; the material is to be supplied by home industry, and in part at least, is Crucible steel. We must assert, and all who have attentively followed the subject will agree with us, that everything is as yet tentative and transitory, and that thus far the results have not been crowned with success. The guns, composites of French and German designs, have been severely criticised by competent jndges, and, according to Lieutenant-Col. De la Rocque, Colonel Maitland, the Direc-

tor at Woolwich, has not met these strictures by the only argument to which there is no reply, "a journal of the proof test of one of these new high-power guns." These animadversions are easily understood, for a system of construction that is not founded on exhaustive tests, beginning with the lowest calibres and rising step by step, is not worthy serious discussion. Then, too, any modifications, extensive or insignificant, made in designs borrowed from one place or another, may entail serious consequences. England has adopted the interrupted screw or French fermature combined, until lately, with the Noble gas-check, a steel cup applied to the face of the breech-screw. Now, however, she has decided in favor of the DeBange gas-check.

While engaged in negotiations with Colonel DeBange, the English authorities also approached Krupp with a view of purchasing a few of his latest designs, but, according to newspaper reports, the measure fell through, as the Essen constructor declined to furnish models, unless as part of a considerable order.

II.—Germany.

Germany is thoroughly committed to steel guns. There are on hand, as can be readily imagined, in the forts and arsenals, a very large number of ordinary bronze cannon, which it is proposed to convert into Uchatius or swaged bronze guns, for siege or flank defence purposes. All the steel guns for both army and navy are supplied by Krupp.

The Krupp cylindro-prismatic wedge fermature has alone been used since 1872, for new model guns; the interrupted screw has rarely been applied, and then only to special pieces, some very small mortars, for instance.

The Broadwell ring, modified, or as originally de-

signed, is the only gas checking device used with German ordnance.

The DeBange field-gun was thoroughly tried in Germany, but the fermature, its only characteristic feature, not only offered no advantage over the wedge, but was actually found inferior under conditions of service.

There are still stored in the arsenal, guns of obsolete model, with Wahrendorff or Kreiner closures, the forerunners of the Krupp system.

III.—France.

France has generally adopted the De Bange system for all calibres. Steel, which has finally been accepted as the only metal to be used, can be made by any of the various established methods, and is supplied in ingots or tubes, by home industry, to the national gun factories. The guns accordingly vary so far as metal is concerned, a drawback in our eyes, for the most rigorous inspection before acceptance does not always suffice to determine its character. We think that purchasing all the finished guns, of one system, from one experienced maker, offers the best guarantee.

The ballistic capability of a system is closely connected with the quality of the gun metal used, hence, where only a single output is used, it is much easier to determine its *law of resistance*, its total capacity for work, and thus readily to solve the problem of charge and projectile.

Even admitting that in France one kind of steel is delivered, as is the case, Open-hearth steel, the question may still be asked, has this metal up to the present time given proof of sufficient resisting power? The instances we have already cited, and others to be presented hereafter, quoted from Colonel De la Rocque, whose

work in this respect may be accepted as trustworthy, show that Open-hearth steel does not always, especially at its introduction, fulfill the high hopes entertained.

We must admit that its advocates had the right to plead in extenuation the novelty of the process, the unforseen difficulties that always accompany innovations, and the inevitable mishaps that attend new methods. But how is it now, has this steel fulfilled its promises? We say it has *not*, it still continues to give unmistakable signs of fickle molecular condition.

The recent casualties to De Bange field-guns, as well as to those of large calibre (see Appendix) are eloquent confirmations of our opinion.

IV.—Austria-Hungary.

Austria-Hungary has a system of construction peculiar to herself; the use of swaged bronze,* whose inventor, General Uchatius, has now been dead some years. This distinguished officer swaged the bronze tubes cold, thus condensing the metal of the bore by pressures exceeding those of the fired powder. He accomplished this by drifting with increasing mandrels.

Uchatius thus greatly enhanced the physical qualities of the alloy, and finding that its resistance had been very greatly increased, he named it *steel-bronze*. Guns of small and medium calibre are made of this metal, and it answers well, *provided high power and longevity are not demanded.*

Several other States have followed Austria's example in using this metal.

The fermature is either the flat wedge or the Krupp cylindro-prismatic with Broadwell gas-check. Some

* Known in the United States as steel-bronze, and patented May 18th, 1869, by Mr. S. B. Dean, of Boston. (O. E. M.)

cast-iron guns, of obsolete model, still have the Wahrendorff breech mechanism.

Although Austria has her gun factories, yet all large calibre sea-coast and naval guns are ordered from Krupp, and even field-guns, which are to be fired with heavy charges, are purchased at Essen.

V.—Russia.

Before 1877, Russia procured her steel guns from Krupp, since that time she manufactures at Obouchoff, cannon strictly after the Essen methods. These Works also make, a new idea in ordnance, pieces with *removable* bore lining.

This bushing is a compressed steel tube, inserted cold under hydraulic pressure. The idea is that when injured it may be removed easily and replaced by a sound one.

This departure from time-honored procedure has naturally led to another novelty, a *jointed* gun, very desirable for mountain and siege service.

The piece is made up of two parts, chase and breech, assembed by means of a screw-collar. It did so well in the war of 1877-78 that the Ordnance Board deemed itself justified in adopting it as one of the standard siege guns.

Russia also makes bronze guns, on Colonel Lawroff's plan, hydraulic compression of the molten metal, but the manufacture is confined to siege and small calibre fortress guns. It is claimed that Lawroff's investigations led to Uchatius's fabrication of steel-bronze.

All guns, except those of obsolete model, have the Krupp cylindro-prismatic fermature with Broadwell ring. Lately some Baranowsky mountain guns have been tried with the French breech, but the results have not yet been published.

VI.—Italy.

Italy has two field-guns, one 7 cent. bronze, the other 9 cent. steel, made by Krupp. In both, the breech mechanism is the Krupp wedge with Broadwell steel gas-check.

Lately the Italian field artillery has been largely increased, and the required pieces were made at home of steel-bronze, but closely following in model the Krupp 9 cent. gun. The 450 steel guns of this calibre purchased by Italy have been apportioned among the fortress parks. As part of the siege and fortification artillery are included a number of 12 cent. guns supplied by Krupp, and cast-iron guns, banded with steel, with French fermature and De Bange gas-check made in the Italian arsenals.

For coast defence, Italy has already purchased 40 cent. guns from Krupp. Navy guns she gets from Armstrong, first of wrought iron, but now of steel, as for instance, the 43 cent. The first 43 cent. guns hooped with steel, were tried in 1884; they fired a 908 kilogram projectile with Fossano powder, and German prismatic, both from Duneberg and Cologne. The velocities were 577 and 590 metres with charges of 365 and 375 kilograms of the latter powder. The lining tube is made up in length of two cylindrical parts, a method of construction that manifested serious drawbacks even during the proof before acceptance.

To sum up, as is seen, Italy is not wedded to any one system or maker; she buys of Krupp, of Armstrong, and steel hoops even of the Creusot and the Bochum Works,

VII.—Spain.

Spain uses steel, steel-bronze and cast-iron guns. A large proportion of the steel guns were made by Krupp.

Guns of other make have a fermature varying little from the French.

Not long ago, Colonel Gonzales Hontoria had constructed at the work-shops of the "Compagnie des Forges et Chantiers" at Havre, a 16cent. steel gun, 35 calibres long, weight 6,200 kilograms, and jacketed after the Krupp system. The proof rounds have shown good results. The metal of this piece, as of all guns made in France, is open-hearth steel, and the fermature, the interrupted screw.

The DeBange [1] gas-check is now undergoing trial in Spain.

VIII.—The Lesser Powers.

The field artillery material of Sweden, guns, carriages, limbers, and caissons, is all supplied by Krupp.

Norway is now experimenting with a new field armament.

The siege and sea-coast guns of the two kingdoms are mainly of cast-iron; the breechloaders have the screw closure with steel gas-check cup. Sweden has, however, in her siege-trains, quite a number of Krupp guns, and the sea-coast and naval ordnance of Norway also includes some 26 and 30 cent. Essen guns.

All Denmark's field artillery is furnished by Krupp. For coast defence she has 35.5 cent. Krupp guns 30 calibres long, and her ships of war carry quite a number of Essen guns, ranging in calibre from 12 to 35.5 centimetres.

Holland has procured all her steel guns, for army, navy, and colonial use, from Krupp. At the Hague Cannon Foundry, experiments are now being made with compressed bronze for low power guns.

(1) And more recently the Freyre. (O. E. M.)

The artillery of Portugal, Switzerland and Greece is supplied in the main from the Essen Works.

All the Balkan powers are supplied with Krupp guns.

Quite recently Servia applied to the Cail Works at Paris, of which Colonel DeBange is General Manager, regarding the supply of 45 DeBange field batteries. As an offset, Krupp has just delivered a new and complete field material to Bulgaria and Turkey.

Roumania has already been, for some time, provided with Essen field-guns and carriages.

Belgium has purchased her field artillery from Krupp. The arsenals turn out bronze and cast-iron siege guns of low power. Her high-power coast and inland defence ordnance is supplied from Essen.

Were we to condense into a few words what we have just written, we should assert that most of the Powers, except France, of course, have for years given contract after contract to Krupp. Such trust, not elsewhere reposed, speaks louder than words for the reputation of the Krupp gun, a reputation based on the excellence of its metal and the superiority of its construction.

No other establishment is better equipped than Essen for keeping abreast with the progress of the times, and the ever-increasing demands of ballistic science.

PART SECOND.

CHAPTER I.

The weakness of the objections raised by the adherents of the French gun against the Krupp.

We have presented the reasons that induced us to prefer the Krupp to all other systems, especially the De Bange.

They were cogent, and led easily to one inevitable conclusion.

Lately, however, numerous murmurs have been heard to the effect that the Essen output had deteriorated, and that the Krupp gun when viewed in contrast with the brilliant success of the De Bange, was only fit for the scrap pile. We cannot cite all the extravagant assertions advanced amid so many clashing interests. We must content ourselves, after having met the arguments common to all those who differ from us, with refuting the conclusions of those whose opinion is of weight in this controversy. We find even this difficult, for their opinions are generally fortified by words, rather than by facts and figures, the only admissible evidence. Still we must undertake the task, for every assertion, no matter how unsupported, masquerades in the garb of truth, and, therefore, requires exposure.

Among the writers who have taken part, directly or indirectly, in the debate on the side of the French system of construction, one, thanks to the wide spread distribution of his work among Belgian artillery officers and manufacturers, has obtained considerable notoriety. We

shall follow his train of reasoning, as the proofs cited here and there, are the same as advanced by the other authors on the same side.

Another work, whose main features we propose to analyze, is Lieut. Col. De la Rocque's book, already quoted. In conclusion we shall have something to say regarding two recently published Parisian pamphlets, one "*Canons francais et canon allemands*," by Captain Mariotti, a well known military writer, the other, "*L'artillerie Krupp l'artillerie DeBange*," emanating from the pen of Lieutenant Colonel Hennebert.

Although some of the pamphlets issued by interested manufacturers, as announcements to influence orders, contain inaccurate statements, intentional errors; on the other hand, Col. De la Rocque's work is characterized by a high scientific standard and by noteworthy originality.

Captain Mariotti supports Col. DeBange's system with rather too much patriotic zeal, still, a praiseworthy spirit, but the courteous treatment he vouchsafes his opponents makes his pamphlet very interesting reading.

We wish we could speak well of Col. Hennebert's screed, but we cannot; every page is permeated by partiality and prejudice, greatly to be deprecated in so important a cause.

As already emphatically stated in the preface, we entertain no desire to be disputatious; free from prejudice, untrammeled by national influences, entrenched in our position as *neutrals* we simply endeavor without ulterior motive to aid those who seek the truth.

In an important expert examination such as this, all Jingoism and material interests should be laid aside and superiority recognized whenever found, precisely as if the question at issue were entirely one of abstract science.

From this point of view we must condemn those zealots who in their endeavor to establish the transcendent merits of the De Bange gun, not only lavish all praise upon it, but go so far as to deny the generally recognized good qualities of the Krupp. This explains their leaving out of account, a prudent omission, on comparing the efficiency of the two guns, the carriage coefficient, for its consideration would compel them to yield the vantage to Krupp.

Before we proceed to test the value of these prejudiced criticisms, we must point out that some of our opponents in making their comparison, use as one term, the Krupp material supplied to the Prussian Artillery in 1873 which was made for lead-coated projectiles.

Now the fact cannot be ignored that Krupp has constructed and supplied to many Powers since 1871 a new field piece with copper bearing projectiles, especially as at the competitive trial at Belgrade one of these pieces was pitted against the De Bange.

Still personalities, in so serious a matter, are of little interest, and we shall at once proceed to meet the arguments advanced by our adversaries, and permit the reader to determine where, with the attack or the defence, the truth lies.

I.—Hoops and Jacket.

Colonel De Bange's adherents claim that hoops increase the resisting power of the tube only tangentially, and add no longitudinal strength.

In this we agree with him, but differ when they assert that with guns of small calibre suitable hammering will endow the metal with exceptional qualities for resisting longitudinal strains, while with guns of large calibre, the inferior metal will require special provisions to enable it to withstand such strains.

This theory is erroneous, for if this difference of construction be essential, the reason must lie in the fact that it is disadvantageous in heavy guns, bearing in mind the duty of the metal in bearing transverse strains, to make the walls thick enough to resist all the longitudinal strain. The jacket, and the double taper hoops used with heavy guns, are not designed to reinforce possibly inferior metal, the same for both light and heavy pieces, notwithstanding the specious pretext of imperfect hammering, but solely to favor the work of the metal of the tube in resisting radial strains, wholly in avoiding a thickness of wall more injurious than useful.

In addition to this, there are other reasons connected with the details of construction, but which, we repeat, have no bearing upon the character of the huge ingots out of which great guns are fashioned.

According to some statements, it might be inferred that De Bange's double taper hooping first solved the problem of longitudinal resistance, a problem with which cylindrical banding could not cope, and that the French constructor had thus discovered a practical means of using heavy pressures in large guns with resulting high velocities. Unfortunately, this method of hooping was not the first solution of the problem, and worse, it does not meet the desired purpose.

In practice, the taper, limited in one direction by the width of the hoop, in the other by the pressure which the exterior is to exert upon the interior hoop, becomes practically so slight, that the tube in which the breech-screw is seated may be torn apart without sensible displacement of the hoops. If the tube be once broken, unbreeching will as surely ensue as with cylindrical hoops. Furthermore the perfect matching and shrinking-on of two conical surfaces, as demanded by Col. De

Bange, is almost a mechanical impossibility ; at any rate it cannot be done by usual shop methods.

On the other hand, the mantle devised by Krupp and adopted twelve years ago, which is shrunk upon the gun-body, and carries by itself alone the breech mechanism, has answered all the expectations of its inventor. To assert that the mantle in one piece applied to field-guns is inferior to the juxtaposed hoops of De Bange, and merits less confidence, would be almost foolhardy. For in the De Bange construction, the breech-screw is carried by the gun-body or the interior tube, which must therefore withstand both transverse and longitudinal strains. Reinforcing the breech with hoops, as admitted by our opponents themselves, has not the slightest value in opposing this powerful effort. It was for this reason that Krupp, who, like everyone else, formerly constructed hooped guns, abandoned the method, and substituted the stronger jacket, or as he calls it, *mantle system.* This mantle, which as the outer coating of the gun, is less directly subjected to transverse strain, bears at the bottom of the breech-slot the whole longitudinal stress, and transmits it through the trunnions to the carriage.

The possibility that the gun may be torn out of the mantle, need not, experience has shown, be feared, as the latter is shrunk on and bears sufficiently hard throughout its length , and after all, in such cases, extended experience is the crucial test.

Some assert that on account of the slot, the breech in the Krupp construction is a weak point, but they forget to add that the mantle at this point is under no transverse strain, and that its designer took care to strengthen it for withstanding the longitudinal effort, which is distributed over the whole surface of the metal before reaching the cross-section most subject to strain, the front face of the slot.

Others allege that circumferential tension can be more accurately attained by small hoops than by large ones. In theory this is correct, but with experienced mechanics and special machine tools, such as Krupp has, there is no difficulty in turning out mantles and tubes, with the desired constant difference of diameter for the necessary length, as shown by the thousands of guns delivered by the Essen Works. Finally, it is assumed that if any flaw exist in this single hoop, it will spread with firing throughout the mantle. The truth is, that there is but very little chance of a flaws existing in Krupp's "Crucible steel," while with the Open-hearth steel, used in the De Bange guns, the conditions are very different. In this latter, the flaw may exist in the tube, as well as in each of the six hoops, and a serious defect in one of these seven parts can lead to the destruction of the gun during firing.

The De Bange method of construction, which has been made to pose as a practical solution of the problem of making the French gun "go," is in reality an evident proof of its inferiority to its German rival.

II. Breech Mechanism and Gas Checking.

We have gathered here the various reasons advanced by the admirers of the French gun in support of their assumption that the De Bange is superior to the Krupp system.

First they cite the fact that as the construction admits of complete hoop reinforcement, the walls of the bore in the French gun are not weakened as in the Krupp. We have already shown that for the whole length of the breech-screw, hooping is of no avail, for only longitudinal strains are here developed.

To meet these longitudinal strains, we recall the fact that Krupp has adequately reinforced the breech of his

gun, and that this increase of cross-section also abundantly makes up for the vent-screw seat tapped into the the breech.

Further, the Broadwell ring, it is asserted, also does its part in weakening the German guns. We take the liberty of again stating that the gun tube does not sustain longitudinal strain, and that the mantle serves as a protection against the injurious effects of transverse stresses.

The objection advanced against the Broadwell ring, applies, with greater force, to the breech threads of the DeBange fermature.

As already shown, these do weaken the tube, as it is subjected to longitudinal strain, and is not itself strengthened to meet this duty, the hoops in this respect being of no avail.

The vent-bushing of the Krupp gun is made up of three parts, a complication, as claimed by its opponents, which must of necessity permit the escape of gas, and consequently, admit of injurious fouling. But they forget to add, intentionally or otherwise, that in order to avoid injurying the foot of the vent-screw, it is recommended that the wedge be withdrawn without shock. By observing this precaution, exceedingly simple, and in fact incorporated in the Prussian Artillery Regulations, all other supposititious ill-effects resulting from the use of the Krupp vent-screw are entirely baseless.

Besides, a similar caution is found in the French Regulations; the De Bange fermature must be worked gently, as rough handling might swell the gas-check packing, when softened by firing to an extent sufficient to prevent the screw's being brought home.

To guard against all erroneous conclusions, we are compelled to add that the common top vent is used by

Krupp only for field pieces, and were it absolutely necessary, it would not be difficult to devise even for this method of venting, a primer that would do away with all possibility of fouling, as has indeed been done already with the Swiss field guns.

For large calibres, Krupp used altogether the axial vent, through the wedge, and all escape of gas is prevented, not by the complicated apparatus ascribed by various authors to him, but by means of the simple obturating primer already described.

In the De Bange gun, its admirers maintain, the breech mechanism is completely sheltered behind the gun ; the breech hoop projecting above the tube affords thorough protection to all the details of the fermature. Against this assertion, we oppose a less flattering one, quoted from an adherent, who has, however, been converted to more orthodox ideas.

"In high-angle fire," he writes, "the breech-screw tends to come out by its own weight, which makes it work very hard ; and, further, it lengthens the gun to the rear very inconveniently."

What one praises as a merit, the other decries as a fault. We must leave to the doctors themselves the task of reconciling these statements.

As a matter of fact, the only parts of the Krupp fermature that project beyond the gun are the crank handle on one side, and the housing on the other ; they are not at all in the way, and require no especial protection. It is very different with the exceedingly sensitive De Bange mechanism, for when open, it far exceeds the Krupp in liability to injuries that may interfere with its regular working.

French writers further sing the praises of the De Bange fermature, on account of its simplicity and small

weight, claiming that it may be dismounted and assembled without tools, while the more complicated Krupp necessitates the attachment of artificers to the battery. This assertion just reverses the facts, the complexity of the De Bange fermature, in comparison with the simplicity of the Krupp, is readily seen by contrasting the descriptions given by these very writers of the working of the two systems.

It is far from our thoughts to assert that the Krupp fermature can be roughly treated with impunity ; *all breech mechanisms, no matter how named, require considerate handling to insure proper and enduring action.*

The De Bange closure is not at all an exception to this law. In the French siege piece, the movable spindle head, the plastic-packing bearing, the screw threads, and last, the vent itself, require careful cleaning after each round, and indeed, also after every round, the chamber must be wiped with a special short-handled sponge, and this done, the female breech plug threads have to be cleaned.

On the other hand, for the Krupp, the only mandatory direction is to keep the gas checking surfaces of the Broadwell ring and the gas-plate clean ; actually though, many rounds may be fired without intermediate preliminary cleaning. As a result of neglect to clean, both the De Bange and the Krupp fermatures may show erosions after a number of rounds, but with this very essential difference, in the De Bange gun they are cut into the very metal of the piece and render it unserviceable ; in the Krupp they are confined to the Broadwell ring and gas-plate, which may readily be replaced by the spare parts carried with each Krupp gun. This operation requires a few minutes only, and does not, as claimed by our opponents, de-

mand the services of a skilled mechanic; under ordinary circumstances, the Chief of piece is competent to make the substitution. The writers on the French side tacitly recognize this facility of exchange, by their recorded admission that the German gas checking system works well, provided ring and plate are properly fitted. It goes without saying, that this condition is thoroughly fulfilled in every gun turned out by an establishment so well stocked with tools, so well supplied with men skilled in their use, and so deservedly proud of the reputation of its output as Krupp's Works.

We deem it of interest to quote here a remark found in the first edition of a work by one of Colonel DeBange's most devoted adherents, which the author (whose name we will not be so unkind as to mention, he, probably, having, like Saul, seen the error of his way), has omitted from the second edition of his work; "In rapid firing, the gas-check of the French field pieces at times gives evidence of decided softening, this can be easily remedied by cooling it, either by plunging in cold water, or simply by wetting with a sponge."

We will add, that during extreme cold, the plastic matter may become frozen, and require heating before a fire, or in hot water, in order to soften the packing.

To avoid this inconvenience Colonel De Bange has proposed that in countries of very low temperatures, like Russia for instance, the tallow of the plastic composition be replaced by glycerine. We have heard nothing of the practicability of this substitution. The French constructor further claims, as an advantage of his system, its uniformity for all calibres. Let us see upon what this claim is based.

The fermature of small calibres carries one gas-check packing-ring, that of howitzers and guns of large calibres, two rings, one within the other. The thirty-four

centimetre gun exhibited at Antwerp had two packing rings. It follows as a matter of course that this variation in the method of gas checking requires modifications of the fermature. The Krupp wedge fermature, with simple Broadwell ring and gas plate, is used in every kind of gun and for every calibre.

In the heavy guns, two additional features have been applied, one to keep the wedge well locked under high pressures ; the other to facilitate its movement. These details of construction add no complication to the apparatus ; it works just as easily. The Krupp field guns need no special charging funnel, and for heavy guns a similar construction has been devised, which requires as the only preliminary to loading, the withdrawal of the wedge.

In all De Bange guns, a charging funnel must be used in order to keep the threaded portion of the tube clear of projectile and charge.

In speaking of the Krupp system, the Kreiner fermature has been mentioned ; we do not understand what connection there can be between two such entirely different methods, and, therefore, will not enter further into the matter here.

It is charged that the Krupp mechanism requires skilled attendants, and demands constant attention, together with the most minute precautions.

The service of the Krupp fermature necessitates no more skill or training, on the part of the cannoneers, than the service of the De Bange, on the contrary, it is acquired more easily and in less time. The casualties which occurred with the De Bange field pieces in the autumn manœuvres of 1885 have shown that, even in the hands of a trained personnel, the De Bange apparatus does not work with certainty. We may well ask, what would happen with untrained cannoneers ?

Krupp's opponents assert that working the handle of his breech apparatus often demands considerable effort; to increase the leverage, a short pipe rammer must then be slipped on the crank, an operation, which as is claimed, causes delay. This may be, but our opponents must admit that this rare contingency, of secondary consequence at best, has been most simply and effectively provided for; in the De Bange fermature, on the other hand, it may occur that the gunner is compelled to work the breech-screw backwards and forwards several times before locking can be accomplished. The reader will recall the minute instructions contained in the Manual, quoted in Part First of this monograph, applicable when No. 2 finds it too hard to open the breech by hand.

One of the weightiest arguments advanced by French authors, one that, in their opinion, furnishes clear, convincing proof of the superiority of the De Bange gun, lies in the fact that England has just adopted the French breech mechanism, that the United States have declared in favor of the system, and, finally, that in the comparative trials at Belgrade this gun came out ahead of all competitors.

England's decision is not at all surprising; for various reasons, the authorities were led to adopt the screw fermature.

In the first place, for the same calibres the wedge fermature requires more massive ingots than the screw; a most important consideration for a country like England, which, as a great maritime power, requires a large number of heavy guns, and it is now acknowledged that the British makers find great difficulty in furnishing satisfactory ingots for the new guns. How would it be if they were compelled to furnish the huge blocks required for the application of the Krupp wedge?

Further, the machining of the wedge fermature necessitates special tools, while the screw can be finished on ordinary lathes. Finally, there were already on hand quite a number of Armstrong guns with screw breech plugs. So much we have to say concerning the fermature itself. With it, until quite recently, was used a metallic gas-check, very much like the Broadwell ring, but it did not give entire satisfaction. Hence, it appeared advantageous to adopt the plastic gas-check which had stood the proof up to a certain point, for small calibres at least.

Whether or no England has acted wisely in preferring the screw to the wedge fermature, is an open question. During the past ten years, English Ordnance has undergone a series of changes; each time, the result was the abandoning of one model which before has been declared the best in the world and the substitution of another, embodying one of Krupp's well established principles, whose adoption had long been bitterly opposed.

We think that even now Krupp can look undisturbedly upon the extension of the enthusiasm aroused on the other side of the channel by the De Bange system.

Indeed it behooves one, if confidence can be placed in the statements of the British press, to accept only with the greatest distrust the conclusions of English Ordnance authorities, as they appear to be as unstable and as uncertain as water. The recent bursting (May 4, 1886), of the "*Collingwood's*" steel gun, occurring so soon after the casualty on the "*Active*," is in this connection exceedingly instructive. For the proper application of this accident, we yield the floor to the English papers.

The Engineer, May 7, 1886, says:

"The piece in question was one of twelve ordered on first approval of the pattern. This is a trunnionless gun

made of wrought iron and steel, being one of the guns that had steel coils in front of the trunnions. After the introduction of these guns, slower powder came in, yielding results with lower maximum pressures, but, of course, continuing high pressures further forward in the bore. This, in conjunction no doubt, with the difficulties attending the introduction of steel ordnance on a large scale, led to the guns being found too weak near the muzzle. One gun burst on board H. M. S. '*Active*' near the muzzle, just as this one has done on board the '*Collingwood*.'"

The Times of May 6, is still more severe in its comments:

"The bursting of a 43-ton gun on board the '*Collingwood*,' which we reported yesterday, forcibly recalls public attention to the grave defects of the Ordnance Department, and the serious risks which we incur as a nation by neglecting to provide a remedy.

The vaunted Woolwich system of gun-making has cost the country an immense amount of money, and has been elaborated with a deliberation to which is largely due the inadequacy of our national defences, now being tardily removed. Expressions of impatience have been met again and again by assurances that delay would be fully justified by the excellence of the gun finally developed, and by our happy avoidance of the mistakes into which more hasty constructors inevitably fell. The type has at length been settled, and, to judge from the sum set apart in this year's estimates for guns for the navy, a serious effort is at last being made to provide armament for our costly ships. The '*Collingwood*' is armed with guns embodying the long results of Woolwich research, and it is one of these monsters which on Tuesday gave way under a charge of powder equal to about seventy-five per cent. of that which would be re-

quired in action. It will be remembered that more than a year ago a six-inch Woolwich gun burst in exactly the same way. That is to say, the fore part of the gun went off bodily along with the shot. An elaborate series of experiments was undertaken to prove the War Office theory, that something must have been accidentally left in the bore which jammed the shot, and so subjected the gun to a wholly abnormal pressure.

Repeated attempts were made to burst a similar gun, by fixing steel wedges in the rifling, but the projectile unfortunately persisted in carrying away the obstruction which was afterwards sifted out of the sand-heaps into which it had been fired. On board the '*Collingwood*' precautions were taken to clear out any possible obstruction by the firing of a scaling charge of seventy-five pounds of powder, so it may be hoped that on this occasion we shall not hear anything of the wedge theory, which, by the way, served no other purpose in the case of the six inch gun than to amuse the public and effect that suspense of judgment which plays so large a part in current politics, until other incidents had thrown the explosion into the background. We shall await with some interest the official defense in the '*Collingwood*' case. The unstrengthened portion of the steel tube has been torn out of the coils shrunk on to strengthen the breech, and the foremost of the coils has itself been ruptured. As Woolwich is responsible both for design and manufacture, and as the design can be vindicated only by proving the manufacture faulty, the dilemma seems tolerably complete, and it only remains to be seen on which horn the Ordnance Department will elect to impale itself."

No more bitter criticism upon the great Woolwich establishment could be uttered. It is true its defenders ascribe the accident to the bad quality of the steel sup-

plied by home Works. The Ordnance Committee, to which Messrs. Armstrong, Abel, Noble, Leece of the Whitworth Works, and Colonel Maitland were added, reported in fact that "the steel undoubtedly exhibited a weak spot, due either to a blow-hole or to some other undiscovered cause, and the factor of safety was too low to meet such a contingency."

Broad Arrow, a Naval and Military Gazette, in its issue of May 8th, 1886, is equally hard on the Ordnance authorities.

"The bursting of the 43 ton breech loading Woolwich gun on board the '*Collingwood*' is another illustration of the inaptitude characteristic of the history of our national armaments. After waiting a considerable time to see what other nations were doing in the matter of heavy guns, the authorities roused themselves up to the necessity of providing the British Navy with ordnance that was to be superior to anything Essen or Ruelle could produce. They, therefore, took away a most promising and efficient officer from his regimental duties and set him down, with no previous training or knowledge as an expert, to manufacture cannon. According to his lights and the resources placed at his disposal, that officer performed more than could have been expected of him, though he was handicapped by the dead-weight of official formulæ.

In the very able lecture which Colonel Maitland gave in June, 1884, at the Royal United Service Institution, it was not a fact of good omen that no two speakers, in the subsequent discussion, could agree generally on the subject of big guns. The theoretical portion of the question was fairly threshed out. The practical portion came last autumn, when out of the four 43-ton guns supplied to the '*Colossus*,' two broke down on trial."

"Both the 6-inch gun on board the '*Active*,' and the

43-ton gun this week, broke at the weakest part where the core looses the support of the jackets."

But the series is not yet ended. In July, 1886, two 38-ton guns were seriously injured on board the English ironclad '*Ajax*.' Our readers will learn the particulars of this accident from a passage, quoted from the French journal, *Le Temps*. In its issue of July 19, 1886, appears the following:

"The *Admiralty and Horse Guard Gazette* reports that the 38-ton guns of the '*Ajax*,' one of the new ironclads of the Reserve Squadron had been rendered unservicable during practice firing in Vigo Bay. One round had been fired from each of the guns in the forward turret, when it was discovered that the bores had been very seriously scored and that the gas-checks had been broken to pieces. Vice-Admiral Baird, in command of the squadron, directed the cessation of practice with these pieces.

This accident, so close on the heels of the bursting of the 43-ton '*Collingwood*' gun has created great excitement in England, for it is certain that the mode of construction must be changed, by no means a small matter.

The new English guns are the outcome of experiments begun in 1878, at the time the Admiralty decided to adopt breech loaders for the armament of its vessels."

Those of our readers who desire to make a thorough study of this subject are referred to the report of Lord Beresford, one of the Admiralty Lords. We have given these few extracts that the value of English Ordnance methods may be appreciated and that the adoption by the Woolwich authorities of the De Bange gas-check, exaggerated and harped upon, may be judged from a proper standpoint.

For a decision to have weight, the essential condition is that the judge must be competent. But the very

comments of the English press have taught us to regard with decided mistrust the conclusions which in the argument we are maintaining the Woolwich Committee appear to have made their own. We can only express the wish that the favor, now shown the French constructor across the channel, may continue longer than was the case with the shoal of inventors who preceded him in the good graces of the Ordnance Committee.

Our readers will have doubtless perceived that the articles quoted from the British papers are a formal condemnation of the policy pursued as well in France as in England, extolled by some as the only rational one, namely: purchasing rough forgings from private Works, and finishing them in government gun factories.

The United States Government has not up to the present time, entered upon the fabrication of its new armament, and has not yet decided in favor of the French fermature.(1) We must conclude that its advantages have not appeared as evident as we are solicited to believe.

Further on in this work, we propose to discuss the Belgrade tests, the adoption of the DeBange gun by the Servian artillery, and also the comments of the military journals, which, on account of this competition, attended by many and various episodes, have taken sides on the Krupp-DeBange question.

III.—Rifling of Uniform and Increasing Twist.

The advocates of the De Bange material inform us—we knew it already—that France has adopted an increasing twist for the gun, and copper slugging bands for the projectile, and that in Germany all guns have a uniform twist, and some, in addition, wedge-shaped grooves, which we did not know, for very good reasons. In their opinion, grooves of uniform twist have the advantage of being easily cut, and of requiring projectiles of

(1) The construction of our experimental guns differs widely from the DeBange method ; the French fermature is applied from necessity rather than from choice. (O. E. M.)

simple construction; on this account, especially, they assert, such grooves were applied to the first rifles.

These statements are inaccurate as far as regards German guns, and the reasons assigned for the adoption of a uniform twist.

All guns made in Germany since the adoption of slugging by means of a single copper band, placed near the base of the projectile, have an increasing twist; there is no deviation from this rule, except where under peculiar circumstances it may have appeared more advantageous to employ a constant twist. The Prussian field pieces, model 1873, have a uniform twist, for at the time of their introduction, lead-coated projectiles were used. Now-a-days, guns can be rifled with an increasing, as easily as with a uniform twist, and require no more complicated projectiles. On the other hand, as long as slugging was accomplished by a lead jacket or by *two* copper bands, placed at the top and bottom of the cylindrical portion of the projectile, an increasing twist could not be thought of, as, under these circumstances, the projectile would have been subjected to torsional stress for the entire length of the bore. But as soon as it was proved that a single copper band at the base of the projectile insured effective slugging, and that the head of the projectile required only to be kept in position and guided in the direction of the axis of the bore, no further objection could be advanced against the adoption of an increasing twist, especially suitable for high initial velocities and very long projectiles.

We must remark, however, that in a field gun of tough metal, an increasing twist is only theoretically advantageous. A single copper slugging band gives, with rifling of uniform twist, the same accuracy, and the maximum gas pressure does not exceed the usual limit.

IV.—Practice of the Guns.

We have already remarked that our opponents, in trying to accomplish their difficult task, the proof of the ballistic superiority of the De Bange guns, strive to lighten the labor by taking for comparison the guns supplied by Krupp to Prussia in 1873, which still used the lead-coated projectiles.

To make the comparison fair, we will take the De Bange 8 centimetre gun, and the Krupp 8.4 centimetre, new model, already adopted by several States, and which was pitted against the French gun at Belgrade.

A.

GENERAL DATA.

		Krupp 8.4 cent. Gun.	De Bange 8 cent. Gun.
Weight of gun	Kilograms.	450	425
Weight of gun and carriage without gunners' seats	"	945	955
Weight of gun and carriage with gunners' seats	"	980	——
Weight of shell	"	7	5.6
Weight of charge	"	1.5	1.5
Mean Initial velocity	Metres.	459	490
Muzzle energy	Metre-tons.	75	68.5

B.

ACCURACY.

Range in Metres.	Krupp 8.4 cent. Gun.		De Bange 8 cent. Gun.	
	MEAN DEVIATION IN METRES.			
	Longitudinal.	Horizontal.	Longitudinal.	Horizontal.
600	4.8	0.06	7.9	—
1,000	5.1	0.17	8.0	0.2
1,500	5.5	0.34	8.2	0.4
2,000	6.1	0.54	8.5	0.7
2,500	6.9	0.82	9.0	1.0
3,000	7.9	1.18	9.7	1.4

C.

VELOCITY AND ENERGY.

Range in Metres.	Krupp 8.4 cent. Gun.			De Bange 8 cent. Gun.		
	Remaining Velocity.	Loss of Velocity.	Remaining Energy.	Remaining Velocity.	Loss of Velocity.	Remaining Energy.
	Metres.	Metres.	Metre-tons.	Metres.	Metres.	Metre-tons.
600	392	67	54.8	400	90	45.7
1,000	356	103	45.2	360	130	37.0
1,500	321	138	36.7	325	165	30.2
2,000	295	164	31.0	300	190	25.7
2,500	275	184	27.0	280	210	22.4
3,000	258	201	23.8	265	225	20.1
4,000	231	228	19.1	245	245	17.1
5,000	212	247	16.2	235	255	15.8

These data, drawn from the official range tables, require no commentary, they prove in every respect the *ballistic* superiority of the Krupp gun.

V.—The Ammunition Supply of Krupp and DeBange Field Pieces.

Our opponents themselves acknowledge that the Prussian field limber carries more rounds than the French ; in this regard the German superiority is evident.

The new model Krupp guns maintain this superiority ; thus the 8 cent. De Bange gun is supplied with 29 rounds, the 8.4 Krupp, with 33.

VI.—Rapidity of Fire of the two Systems.

Rapidity of fire, we are told, does not depend so much upon the rapid service of the piece as upon the facility of supplying ammunition. So far as we are concerned, we do not object to this dictum, are even willing to make it our own. The most important consideration affecting this facility of supply is evidently the method of stowing the ammunition in the chests. In this respect the Krupp chest is beyond criticism ; even the French Ordnance Corps have recognized its merits, for they have adopted an identical method.

As regards the rapidity of fire of the Krupp field gun, the test to which it was successively submitted at Belgrade, May 6, 1885, proved, without a shadow of doubt, that in this respect also, the German gun was the peer of the French.

The gun tried was the same which December 4, 1884, owing to neglect in the manipulation of the fermature, required 33 minutes for 30 rounds in the rapid firing trial, while the De Bange delivered the same number of of rounds in 23 minutes.

These figures were given in the French reports. They were so surprising that the test was repeated. The Krupp gun was made ready for the practice without difficulty, and on May 6, 1885, the second test took place in the presence of the Board that conducted the comparative trials, and of Krupp's representatives. The gun detachment were Servian artillery-men, and the conditions were precisely those governing the test of Dec. 4, 1884.

This time the German gun fired 30 rounds in 16 minutes, while the French gun, as already stated, had required 23 minutes.

VII.—The Elevating Screw of the two Systems.

The Krupp gun is pointed by means of a double elevating screw upon whose head the breech of the gun freely rests. This arrangement is very simple and works well, as shown by the accuracy of the piece.

The objections to this method are entirely imaginary, and there is not the slightest use, in our opinion, for employing the complicated De Bange mechanism.

The Krupp 8.4 cent. gun can be depressed 8° and elevated 24°, the 8 cent. De Bange 6° and 26° respectfully. The statement of the author who writes, "the French elevating apparatus allows the piece to be elevated 24°, while the German gun can be elevated only 18°," is of no value, for it has no application to Krupp's recent models.

The same author continues in this strain :

"In heavy guns, France has done away with breech preponderance ; in field guns, however, it is still required, for they sometimes receive shocks which otherwise would overturn them."

For years these two principles, the necessity of preponderance for field guns, and the possibility of doing

without it in heavy guns, have been accepted and applied everywhere. Hence this digression is either purposeless, or it would seem to mean that upon this question the French construction has followed in the wake of others, which is not the case. We hold French Ordnance Officers in too high esteem to believe that their suppression of breech preponderance in large calibre guns was deemed a novelty.

VIII.—Fuzes.

The manufacture of fuzes is one of the specialties of the Essen Works.

Percussion, time and combination fuzes for short as well as long ranges are fabricated. The care exercised in their construction and workmanship and their certainty of action are known to such hosts of military men, that no defence is required here. Krupp has no need of seeking models abroad; he can supply his own and guarantee their reliability.

According to newspaper reports, Colonel De Bange, having no fuze of his own, supplied fuzes of Swiss manufacture, with the material purchased by Servia.

IX.—Collar and Breast Harness.

There are two kinds of harness, collar and breast; it is difficult to assert positively that one is better than the other; the choice would depend upon the special conditions of the case, or upon personal predilection. The German artillery uses collar, the French, breast harness. Krupp supplies one or the other as may be desired. A number of artillery officers have declared for breast harness, and base their opinion upon the favorable French reports regarding its use in the war of 1870–71. Against these reports, we cite other, as conclusive, ones made by the Germans, who also went through this war of 1870–71, and yet retain their har-

ness. And we reply to the arguments advanced in France in favor of breast harness, by inviting attention to this rather curious fact, that the De Bange carriages furnished Servia will be drawn by collar harness, and still more singular to relate, an adjustable collar of *German* invention will be used.

The Belgian Artillery is generally well satisfied with the collar harness heretofore used.

X.—Mountain Batteries.

France has mountain guns on account of possible Alpine or Pyrenean campaigns, but Germany has no important mountain frontier, and it is not, therefore, probable, under present circumstances at least, that her Artillery will have occasion for the use of such guns.

It is not surprising then that this gap, if one can speak of wanting that for which there is no necessity, exists in the German material.

But the Krupp Works supply mountain batteries constructed on the most approved model, and have sent them to all quarters of the globe. It is well known that the English deemed themselves fortunate in finding at hand for their Soudan campaign, the Krupp mountain guns purchased by Egypt, and, even before this, these small calibre Krupp guns had played a most important part in Spanish and South American warfare and in the Dutch Colonies.

Hence it seems a work of supererogation to attempt to prove at this late day, by experience of the Tonquin campaign, the utility, never denied for particular cases, of mountain artillery.

Everybody acknowledges the services it may render under fitting circumstances.

CHAPTER II.

The French and German Systems of Gun Manufacture and their Results.

I.—Gun-Metal supplied by Private Industry, the French System and the Krupp Monopoly, the German System.

Much praise has been awarded the French system of gun manufacture, under which the rough forgings are made at private works, and assembled and finished in the Government factories, while in Germany, the Krupp Works monopolizes the fabrication.

In support of their preference, the believers in the French system advance the following arguments:

First of all, it encourages home work. The fostering of native industry is, undoubtedly, correct *in principle.* But when such protection demands the expenditure of enormous sums by Government without adequate hope of reimbursement through the industry in question, or when the possession of inferior guns might enfeeble the military prestige of the State, all must agree, except possibly those personally interested, that true patriots, worthy the name, should be willing with one accord, to sacrifice commercial profits, inconsiderable with an active army of limited strength, for the sake of the national defense.

This view will hardly please those Belgian manufacturers who dabble in guns; in regard to this we could

"a tale unfold," but we are here influenced by but a single consideration; the search for the best tool, the best arm.

It stimulates, they add, the zeal of Ordnance Officers.

Many inventors in a military corps, is a matter of doubtful advantage, and all must admit that the French policy is open to the objection of instability of tenure, as regards the administration of the State factories. We do not know whether sufficient time have elapsed to make this objection felt in France, but in England, where the same policy has been pursued for years, its full weight has been felt, especially at Woolwich. This could have been anticipated; for no sooner have officers detailed on ordnance work become thoroughly familiar with their technical and administrative duties, than, for the sake of promotion, they must be relieved by others, who again must serve an apprenticeship before becoming skilful in their new profession.

Finally, it is claimed, this policy permits the division of the work among several establishments.

We do not believe any Government can keep different plants, *completely outfitted for gun-work*, going. Such a method, like every other, would result, either in an impartial allotment of the work, or in its concentration in one establishment.

This applies with equal force to the fabrication of ingots. There cannot thrive in a country a whole series of plants for turning out steel masses of the superior and uniform quality required for gun-metal. Even in France, there is already apparent a tendency to establish a distinction between Creuzot and Saint-Chamond Open-hearth steel; in England, Firth alone produces Crucible ingots for cannon; in Russia, the Obouchoff Works supply the finished guns; in Germany, finally, this is done by Krupp.

It is, accordingly, an open question which of the two policies is the best, but we can assert that results speak decisively in favor of the German method. And we are convinced, in face of the complaints presented to the Reichstag by Representative Berger, *who at the very time was the owner of a steel plant*, that Germany has never regretted permitting the Essen Works to monopolize her gun fabrication.

Even if it be conceivable that a great nation, endowed with vast industries, should, at a given time, deem it its duty to undertake its own gun work, and to aid the development of private plants by purchasing the required ingots, when, as the report of the U. S. Gun Foundry Board shows, their manufacture cannot be undertaken *without large and frequent subsidies* ; even then, a similar procedure on the part of a smaller State would entail expenditures out of all proportion. Hence, such a State, as a matter of highest duty, for the sake of its own security, should purchase, no matter where, the *very best* ordnance.

For this ordnance, it must go to Essen.

Considering all that has been said upon the subject, we would be justified in making no further attempt to establish this conclusion ; but we have still in reserve some additional cumulative arguments, the effect of which will be the dissipation of the last remnant of doubt that may yet rest in our readers' minds.

The essential features of modern artillery are determined by three conditions:

1.—Maximum ballistic efficiency, that is, greatest accuracy and energy.

2.—Ease and certainty of manipulation, combined with endurance.

3.—Minimum liability to mishaps.

Each of these necessary conditions is again dependent upon these three concomitant elements :

(*a.*)—The design of the gun.

(*b.*)—The workmanship.

(*c.*)—The quality of the material.

The ballistic superiority of the Krupp over the De-Bange gun, was clearly shown in the exhaustive comparison given in Chapter III of this monograph.

The Krupp gun would have even a greater lead were we to institute comparisons with the Armstrong, but this is not necessary, for it is admitted that the English engineer has been distanced by his French and German competitors.

Quite recently, at the Bucharest trials, in December and January of last winter, the construction and equipment of the 21 cent. Krupp mortar attracted, justly too, the special attention of all the experts present, and notably, the French.

We have already made clear the advantages of the Krupp closure compared with the De Bange, but we reserve the privilege of returning to the subject again in our proposed critical discussion of the Belgrade tests. The long service life of the Krupp gun is established by varied experience. In Belgium, we have a 9 cent. Krupp which has fired several thousand rounds and is still in perfect condition. (*Cours de l' é cole d' application de l' artillerie et du génie de Belgique.*) During the winter of 1880, two Krupp siege guns, 10.5 and 12 cent. calibre, were fired for endurance about 1000 rounds each, without perceptible scoring or diminution of accuracy.

As regards ability to stand the vicissitudes of the march, by no means an unimportant consideration, the Belgrade experience is conclusive, the Krupp 8 cent. mounted gun, endured all the carriage tests without the

slightest injury, while both the De Bange and Armstrong guns were damaged in many ways. But above all technical claims, far outweighing the results of the firing ground, is the supreme and decisive test of actual warfare ; from it there is no appeal. The Krupp gun is the only one which during the European and American wars of the past two decades, has demonstrated its perfect efficacy under all the varying circumstances of numerous and severe campaigns.

The Krupp guns offer the best guarantee against casualties. The number of burst guns is indeed insignificant, hardly appreciable, in comparison with the number turned out at Essen, over 21,000, and these accidents all occurred to obsolete models. This question we shall thoroughly examine further along.

Again, it must not be forgotten that the Krupp Works is better able than all others to obtain a high standard of excellence for its products, inasmuch as it has at command everything necesary for the continued improvement of its output, and is always kept posted as to what is doing in the various States whose ordnance it supplies. Then too, the Works possesses a body of engineers and mechanics, trained in all the untold difficulties of fabrication ; a matter of vital importance, for ordnance construction is controlled by complex laws, which demand in their observance great scientific and practical knowledge, and no establishment can undertake gun work of special design and quality by merely providing a first class mechanical outfit. Finally, we must not overlook the fact that the Essen Works turns out in its famous Crucible steel the only metal really able to meet the ballistic requirements of the day, and the good quality of the metal is, after all, the very *foundation* of gun construction.

II.—French and German Gun Steel.

Notwithstanding the contrary statements of rival establishments, it is an undeniable fact that in cannon manufacture, Krupp uses only Crucible steel of special make.

From the smallest to the largest gun, not a particle of other metal is employed, in tube, in mantle, in hoops, or indeed, in any portion of the construction. The raw material of the Krupp Crucible steel is made up of remarkably pure ores, producing a special pig, itself again converted into puddled steel in a puddling furnace.

This steel, in conjunction with iron puddled for the purpose, makes up the crucible charge for remelting into *Crucible steel* of the required tenacity and of absolute homogeneity. The ore used in the fabrication of this steel is drawn from mines belonging to the Krupp Works, and every process to which it is subjected, from the very beginning, to the forged block and completed gun, is carried out in Krupp furnaces and Krupp shops. The German constructor carried on the manufacture of Crucible steel on a grand scale before the Bessemer and Open-hearth methods were known; his process has the sanction of long experience, and, while formerly tentative, is now based upon scientific principles. To those who say to us, "Colonel De Bange deems it of little importance who supplies the steel, or how it is made, provided it comes up to specification," we answer, that we consider the ennunciation of such an opinion a purely individual matter, for we have too high a regard for the French constructor's ability, not to be convinced that, even if he accept this *dictum*, he does so under stress of circumstances, and that, had he free choice, he would not hesitate an instant to obtain metal of *absolute* guarantee, in following the Prussian system.

It is fallacious to assume that specimens, cut from a steel block for shock and tension tests, determine its mechanical properties. The experiments of the French Marine Artillery are a sufficient proof, as appears from Colonel De la Rocque's testimony. This experienced officer of rank, in his "*Étude historique de la résistance des cannons rayés*," already quoted, writes thus of the period from 1860 to 1871.

"The steel which our makers were able to supply did not offer satisfactory guarantees. It had defects of every kind, coarse and crystalline grains, making up a lumpy and seamy mass, *whose ends and surface appeared all right*, blow-holes and other breaks in the fibre, due to various causes which combined to shake confidence, even under conditions of fire far within the mean resistance of the metal."

In reporting upon a more recent period, the author continues:

"Consequently, the conclusion was drawn that steel, which at this time (about 1872) could not offer absolute guarantee, even for 24 cent. *tubes*, was unfit for the comparatively thicker *bodies*.

The fissuring of two 24 cent. guns, both opening more than one millimetre, actual cracks, the blow-holes, the *spongy spots* characterizing the whole bore, must have confirmed the heads of the Naval Ordnance in their often announced decision, that steel was still a hazardous metal to use, and therefore unfit for gun purposes."

The following from the same author is quite as interesting:

"Taking together the facts already cited, others less important but equally significant, as for instance, the breaking off at Ruelle of the chase of a 24 cent. gun (fortunately with a long tube) at the fifth proof round, a break ascribable to a blow-hole extending almost over

the whole section; circumstances noted during practice, during machining, in the turning out of the rough parts, all combine to establish incontestably the truth of the conclusions reached in 1874 and 1875 from actual trials, regarding the 24 cent. steel guns.

During this period, from 1875 to 1881, up to the very time of the setting up of the Creuzot and Saint Chamond 80-ton hammers, the substitution of steel for cast-iron, while trebling their cost, had not increased the ballistic power of heavy guns; it had, however, delayed for some years coast defence armament, and to avert the dangers due to the use of defective steel forgings, it was necessary to have recourse to safeguards out of use, and needless with lined and banded cast-iron guns."

To conclude, Col. De la Rocque speaks thus of the period of 1881–1885 :

"We shall, as regards these years, here enter into no details. French makers are supplying tempered steel with a minimum elastic limit of 32 kilograms. Mechanical and powder tests are increasing the rigor and precision of the inspection of their deliveries, including tubes, gun bodies and hoops."

These quotations, drawn from an author certainly not inimical to French steel, as shown only too clearly by the last passage cited with this very purpose in view, prove that the mechanical tests before acceptance, do not suffice to establish the integrity of the steel block. Further, a *few* rounds fired without accident from each piece, or endurance tests with a *limited* number of guns, do not establish the *excellence* of the material used. Of course, these tests can in no case be omitted, but to establish confidence in steel as gun-metal, the mode of fabrication must, in addition, in itself guarantee its homogeneity, and of course it is still better if the possession of this quality has been demonstrated by successful

proof, extending over a long period of time, and embracing a *very great number* of guns.

These are the controlling reasons which have impelled Krupp, notwithstanding the example of Colonel De Bange and other makers of equal reputation, to continue making guns of crucible steel alone, high as regards cost of production, it is true, but of incomparable homogeneity and trustworthiness. Still, owing to unparallelled manufacturing facilities, Krupp guns cost no more than their competitors, constructed of decidedly inferior material.

III.—The Accidents to Krupp Guns.

We might, at this stage, consider the discussion closed, did we not deem it a duty to disprove certain erroneous assertions set up by Colonel De la Rocque in his book.

An advocate, as are many of his comrades of the Marine Artillery, of lined and banded cast-iron guns, Col. De la Rocque, compelled to put up with steel, rebels decidedly against Krupp steel, the very metal which has forced him and his school to a change of opinion.

We can readily understand that, after the unfortunate French experience with Creuzot and Saint-Chamond steel, this distinguished officer, compelled by the logic of events to accept this metal, is not an extravagant enthusiast. Still, it seems to us that in his character of author, he has overstepped the bounds of criticism to give free rein to his disappointment, and the better to defend his inclination, painfully apparent, for lined and banded cast-iron ordnance, in charging up against the German guns a long tale of mishaps, whose character and scope he changes entirely by his accompanying remarks.

Colonel De la Rocque's list of accidents comprises thirteen cases. By adding the Glogau casualty, cited by

other writers, we have a total of fourteen, distributed among over 21,000 guns.

This is insignificant, but we hurry to the rescue and acknowledge twenty-five; twenty-five accidents have indeed occurred with Krupp guns during the period of thirty years!

Sixteen of these occurred *before* 1868, and were due, either to demanding too much from the solid guns of the day, without mantle or tube, or to defective construction, that is, the use of a rectangular wedge with unfilleted breech-slot angles, or finally, to the improper manner in which the pieces were tested.

Seven of these sixteen accidents, happened to Prussian field guns, for which Krupp supplied the forgings, but which were finished at the Arsenals.

This model was abandoned and replaced by one having slots with well-rounded angles. *Not one of these* belied the promises of the constructor, notwithstanding the exhaustive and unusual proof they received in the war of 1870–71, during which some of them were fired an excessive number of rounds. In the Loire campaign, for instance, a Krupp gun delivered in a single day 300 rounds.

Of the nine cases occurring since 1868, two happened to *solid* guns, two to field guns, damaged in the chase by premature explosions, and the other five, to hooped guns of obsolete model, due either to overstraining or to wedging of the projectile.

We, therefore, feel justified after thus detailing the real facts, in declaring unwarrantable and not in accordance with the truth, the conclusion which Colonel De la Rocque thus formulates:

"These instances clearly show the insecurity of the system." On the contrary, nothing can demonstrate more clearly the security of the Krupp system than the astonishingly small number of accidents, of well-defined

character, which are chargeable to 21,000 guns, supplied to most of the armies of the civilized world.

IV.—The Accidents to French Guns.

French writers, who dwell at length upon the casualties to Krupp guns, *exceedingly serious*, they call them, though we now know how to take this, still acknowledge that some slight mishaps have occurred with De Bange guns.

"Accidents have recently occurred in France," says one, "but they are of no importance, they are of daily occurrence."

We might have expected this, what is criminal with Krupp, becomes trivial with De Bange. But for what can they be striving, who, passing their time in foisting upon Krupp guns, accidents said to have occurred at Constantinople, Cairo, at any rate so far away that little opportunity for personal confirmation is afforded, yet assert that "accidents of daily occurrence," prove nothing?

The *Progrès militaire*, which, as all the world knows, has no acquaintance with Colonel De Bange, considers it a grievance that Krupp publishes, far and wide, a list of casualties to French guns, and carries its assurance to the point of finding fault with the Essen manufacturer, because he printed this list at his Works.

To us, Krupp's open method of fighting seems manly. Between it and that other method, which consists in spreading false rumors through the press, sensational accounts of burst guns, we do not hesitate to choose, and Krupp, whose scientific and technical reputation precludes resort to such contemptible means, does not need to have recourse to the petty devices followed by certain newspapers in the pay of his detractors.

It is admitted, then, that accidents do happen to the De Bange guns—what are they, and of what nature?

There are some, according to the statements of the *France militaire*, which lead one to suppose that the tube has been torn off *with completely closed breech.* We find namely, to be more exact, in its issues of July 5 and December 10, 1885, a report of accidents of this kind which happened to a 9 cent. De Bange, a 9.5 cent. Lahitolle, noticed too by *Progrès militaire*, and to two other field pieces, also in all probability, De Bange guns.

In its issue of September 6, *France militaire* prints these pertinent words:

"After having spoken of the bursting of practice guns, *bursts more frequent than is generally supposed* etc."

This remark, made by a French journal, should induce hesitation on the part of those who are infatuated, far more than necessary, with the *French* construction; it certainly is not very encouraging.

The tearing off of the tube may be due either to faults of construction inseparable from the screw, the longitudinal strain acting too suddenly upon the bottom of the threads, to the inferior quality of the steel, or to both combined. The tube of the Lahitolle gun has at the bottom of the threads a section of 3.7 square centimetres per square centimetre of chamber section, while in the two De Bange guns the ratio is only 3 square centimetres.

We are, therefore, of the opinion that, in both instances, this kind of accident admits of the same explanation, the concurrent action of both causes mentioned above. In 1864, similar casualties occurred with the recently adopted Prussian light field guns; they were at once withdrawn, and replaced by a new model. We are not gifted with second sight, and cannot therefore

predict that a similar fate awaits the French guns, but the coincidence is curious and worthy of note. From the summary of accidents to the De Bange, two more are to be specially noticed.

They occurred, according to *France militaire* of September 6, 1885, "because the piece had been fired without assurance that the breech had been carefully locked." This explanation *Progrès militaire* would like to apply to all the De Bange accidents; but this endeavor is merely a joke of doubtful taste, for the language of the French military press is too clear upon this point, and it is evident that if the mishaps were all due to this defect in the construction of the fermature, a remedy would long ago have been provided.

The accidents to De Bange guns aroused general anxiety in France, the effect of which was felt in the Chamber of Deputies.

On January 16th, 1886, M. Lejeune introduced a resolution calling for a report from the Minister of War upon a letter from General Campenon, in which he uses the following words:

"Upon the occurrence of the first accident, the unbreeching of a 9 cent. gun, I directed immediate search for a breech mechanism *offering entire security*." At that time, then, in the opinion of General Campenon, the screw fermature with De Bange gas-check, did not possess this desirable quality of security.

General Boulanger, after three guns had been unbreeched during the grand manœuvres, announced that the defect had been cured, and that, thanks to a small locking finger, soon to be applied to all guns, there would be no more of these accidents. We will round off this announcement with a word. The *Indépendence belge* of Sept. 13, 1886, reports the bursting of a field piece, the blowing off of the breech killing one man, Sept. 9, during the minor manœuvres near Avignon. We do

not deem it out of place to ask whether or no the locking finger had already been applied to this gun, and, should this question be answered in the negative, to inquire why officers and soldiers, after the lesson of all previous accidents, had not been so emphatically warned in regard to premature firing, as to make repetition impossible?

We consider these facts as confirmatory of our opinion that the *innate* weak spot of the French field pieces is brought out by accidents due to the natural tearing off of the breech, accidents which cannot be explained away by ascribing them to negligent service. This latter difficulty may be overcome, but the former, hardly. But there is more to come. *France militaire*, in the issue of Oct. 11, 1885, reports the breaking of a portion of the chase of the first two 42 cent. guns, built up entirely of steel, during their proof at the Ruelle foundry. These accidents, like the others, must be due either to faulty construction, unsound metal, or to both.

The correspondent of *France militaire* appears to lean to the latter alternative.

Now, the De Bange guns are made of the *same* metal as the 42 cent. guns, the *same* as those of the French Marine service, so that as far as the reliability of the metal is concerned, the serious aspect of accidents to one applies to the other.

We learn further that in consequence of improved methods of determining interior pressures, it was shown that the *unhooped chase* of the 15.5 cent. De Bange gun was not quite strong enough to sustain the pressure of the 9 kilogram maximum charge of slow burning powder, which was therefore, as a measure of precaution, reduced to 8.75 kilograms. With all confidence in the deductions of French Ordnance Officers, we yet cannot persuade ourselves to believe that with a given system of construction, the reduction of the maximum charge

of a 15.5 cent. gun by ¼ of a kilogram will assure the security before wanting. Indeed, if the absence of chase hoops were the cause of the casualties to the 42 cent. guns, their absence on the 15.5 cent. De Bange gun, which now seems too weak, affords much food for thought.

The only accident to De Bange guns which has come to the knowledge of the *Progrès militaire* we will gladly pass by without remark. We are compelled, however, to say that this paper deceives itself in asserting that the Krupp Works alone draws from these accidents mentioned, conclusions unfavorable to the De Bange system ; all impartial experts must surely have come to their own conclusions, and we doubt, if they be favorable to the material lauded by *Progrès militaire.*

When, at the beginning of 1885, Colonel De la Rocque wrote, "—the French Marine Artillery has achieved, even with steel guns, a positive progress, which abroad is still a matter of theory or dependent upon manufacturers' promises, conditions whose fulfillment heretofore was not exempt from service failures or from grave mistakes," this prominent officer little thought, that a few months later, the bursting at the Ruelle Foundry of two of the largest calibre guns of the Marine Artillery would point so cruel a moral, while Krupp's still larger guns stood most successfully their proof at the Meppen firing ground.

V.—The Development of the Krupp Gun.

A retrospective summary of the history of Krupp guns, it seems to us, would add value to our discussion. In his work, "The Development of the Prussian Seacoast and Naval Guns from 1860 to 1878" (Berlin, 1879) Major H. Mueller thus expresses himself : "Austria and Prussia had, toward the close of 1867 adopted breechloading guns with lead-jacketed projectiles. The

method of hooping proposed by Krupp, as well as the interior construction of the bore, had not yet at this time, been positively determined. Further great difficulties were still to be overcome in securing a sufficiently strong, thoroughly gas-proof breech mechanism ; the problem of proper material and bearing for the projectile had not yet been solved, and the question of powder was still under examination."

As correctly stated by the author, Austria and Russia adopted in 1867 the Krupp gun, hooped, with his cylindro-prismatic wedge.

The Prussian Ordnance Corps could not yet however, decide to abandon the double wedge with copper gas-check. It continued its investigations and later experiments confirmed the value of the constructions proposed by Krupp.

Lieutenant Colonel De la Rocque is unwilling to yield the palm of seniority in merit to the Essen constructor, for in connection with his account of the bursting in May, 1867, of a Krupp 21 cent. naval gun, he draws this conclusion :

" To sum up, at the close of 1868, the Krupp Works had not produced a 21 cent. gun capable of firing with safety a charge of from 9 to 12 kilograms, and a projectile of 85 kilograms."

The author is plainly in error, let us repeat the facts. In May, 1867, two *solid* 21 cent. Krupp guns were put to *proof*, one with the Kreiner fermature, the other with the Krupp, and during the firing, the steel gas-plate and the front wedge of the former broke.

Hence it required more than good wishes to father this accident upon *Krupp*.

The breech mechanism was replaced, and the firing continued without interruption. Colonel De la Rocque indeed silently acknowledges the injustice of the charge

in writing, " this accident led to the abandonment of the *double wedge*, and, in July, 1867, 20 guns with cylindro-prismatic wedge were ordered of Krupp."

The French author further writes : " On January 27, 1869, another 21 cent. gun burst, during experimental firing, after having stood 500 rounds ; its chamber having been gradually enlarged to receive charges from 9 kilograms upwards."

This records the bare fact ; it should be added that this was the second of the two 21 cent. guns whose proof was just concluded ; that 650 rounds had been fired with charges varying from 8 to 12 kilograms, and that the piece burst under the pressure due to 12 kilograms of prismatic powder, after some experimental rounds with a very quick *baryta powder*. We invite Colonel De la Rocque's attention to the fact that he has not correctly comprehended the German text of Major Mueller, whom he cites as authority for his statements. We oppose to the conclusions of the French author, those of Captain C. von Doppelmair of the Russian Artillery, who does full justice to the merits of the Krupp gun. His paper, published during 1869 in the *Russian Artillery Journal*, is entitled : " The heavy steel breech-loading Prussian and 9 inch Woolwich gun," and is based on the results of the comparative trial carried on in 1868 at the Tegel Firing Ground near Berlin.

The article was translated into French by Lieutenant Colonel Martin des Brettes (Paris, 1870), and into English by G. H. Penton (London, 1870). According to this account, the Krupp guns triumphantly sustained the endurance tests, and proved themselves fully able to meet all the demands of actual warfare.

The following table, which is also given by Major Mueller, requires no comment in explanation.

KRUPP STEEL GUNS, ABOUT THE CLOSE OF 1868.

	Solid Guns.		Hooped Guns.		
Calibre of gun . Millimetres.	203.2	209.2	228.6	235.4	279.4
Weight of gun . Kilograms.	7800	6750	14,800	14,650	26,000
Weight of charge . . " .	10.25 to 12.9	9 to 9.5	18.5 to 21	24	37.5
Weight of projectile . " .	82	102.5	125	153	225
Number of rounds fired in endurance test	1205	638	825	676	400

All these guns, after the rounds given in the table, were in excellent condition, with the exception of the 23.54 cent. gun, the bore of which was injured on the 662d round by the explosion of a chilled shell.

Notwithstanding the weakening effect of these injuries, the gun, according to Major Mueller, fired thirty-six additional rounds without diminution of accuracy.

We cannot better show the superiority of the German heavy guns of this model to their French banded cast-iron rivals, than to compare Captain Doppelmair's figures with those in the subjoined table, given by Colonel De la Rocque.

CAST-IRON, BANDED FRENCH GUN OF LARGE CALIBRE, ABOUT THE CLOSE OF 1868.

Calibre of gun . . . . . Millimetres	194	240	274
Weight of gun . . . . . Kilograms.	8,050	14,550	22,000
Weight of charge . . . . "	12.5	24	36
Weight of projectile . . . . "	75	144	217
Life of gun, fixed at rounds	600	500	300

The French guns were breech-loaders, but did not use lead-jacketed projectiles, a condition that gave rise, according to Colonel De la Rocque, "to windage, a danger to the bore and a drawback to the smooth movement of the projectile."

On the other hand the more efficient Krupp guns were not only breech-loaders, but also used, thanks to their lead jackets, slugged projectiles.

Since 1867, the reputation of Krupp heavy ordnance was so firmly established that in 1868 and 1869, the Essen Works supplied Russia with a considerable number of the 23 and 28 cent. guns included in the above table.

"Deep disappointment," says the French author, "very soon arose."

This is far from the truth, for it must not be forgotten that Russia, profiting by the experience gained at the Krupp Works, established about 1869 a Gun Foundry, planned directly upon the German establishment.

Since that time Russia herself produces Crucible steel upon the identical method followed at Essen, and constructs guns of Krupp model, in whose designing Russian officers had assisted. Notwithstanding these favorable circumstances, Russia has continued to purchase guns from Krupp ; indeed all foreign orders have been given exclusively to the German constructor—new and unimpeachable evidence of the excellence of Krupp's metal and construction.

Prussia, during the years 1867 to 1869 purchased a number of these Krupp guns of large calibre.

The esteem thus shown Krupp by two great military powers, explains how it came about that he exhibited at the Paris Universal Exposition of 1867 a 35.5 cent. hooped steel gun weighing 50,000 kilograms, which attracted such general attention in France.

This gun would doubtless have given as satisfactory results as the 28 cent. guns furnished Russia, but as it was known to be too short, and as it had already been determined to replace it at once by a longer model, an endurance test would have been not only costly, but useless. We cannot attempt to correct all the errors concerning Krupp guns with which Colonel De la Rocque's book teems, we will, however, quote and analyze two more passages, to show that the author has either drawn from unreliable sources, or incorrectly translated the German text.

" During the summer of 1876," he writes, " experimental firing with the second 26 cent. gun made by Krupp was resumed, charges of 47-48 kilograms being used. With a chilled cast-iron shell of 187 kilograms and 48 kilograms of powder, a velocity of 490 metres was obtained. The construction of these pieces began at the close of 1876, and an endurance test was determined upon.

The first firing took place in 1877; 423 rounds were fired, 315 with charges of 47 to 48 kilograms. After 158 rounds, the enlargement, extensive for the whole length of the chamber, had reached two millimetres. Deep erosions were found at the beginning of the rifling. The gun was pronounced unserviceable. In 1878 it was used in experimental practice and fired altogether 709 rounds."

We make a simple, but rather important correction; it was not after *158* rounds that the havoc described by the author was observed, but after *709* rounds, surely a very different state of affairs.

If Lieutenant-Colonel De la Rocque will reperuse the text of Major Mueller, he will find that the enlargement of the chamber was due entirely (Report of the Prussian Ordnance Board) to the imperfect slugging of the projectile. The substitution of copper bearing bands for the lead jacket proved a cure. In the following extract the author again misinterprets Major Mueller's idea.

"In *imitation* (*'after the manner,'* is the correct translation) of the French Marine Artillery, the Krupp Works constructed in 1875 the first so-called Mantel-Ring-Roehre, jacketed and hooped guns, and—"

The *body* of the French guns is derived from the cast-iron body of the obsolete constructions.

Its object, unlike the Krupp mantle, is not to relieve the tube from longitudinal strain.

Even if the gun had *at the same time*, both *body* and *tube*, the latter would still carry the closure; and if a special *base-ring* were interposed, as nut for the breech-screw, it yet would have to be screwed both into the body and on the tube.

On the other hand, the Krupp mantle was designed from the very beginning to carry the breech mechanism, that is to say, it *alone* was to take up the *longitudinal* strain. Hence the French *gun body* and the Krupp *mantle* fulfill altogether different functions.

In concluding this question, we must protest against the method followed by Colonel De la Rocque in taking as his standard for judgement the Krupp guns of large calibre *now used by Germany.* Most of the heavy German naval and Prussian sea-coast guns are *conversions of obsolete models*, that is their ballistic power has been increased by certain structural modifications. It is readily understood that the efficiency of such ordnance does not rank high, and that it is not always proportionate to calibre. We repeat what we have already said; we must not lose sight of the fact, that, by this means, Germany has kept, without great expense, in the track of modern Ordnance progress. All must acknowledge that this consideration has weight. Colonel De la Rocque is not justified in impugning the data published in the Krupp Firing Ground reports, as exceptional, as dressed up for a special purpose. Though the Krupp work-

shops are barred against investigation for personal benefit, the Essen proving grounds are open to the inspection of all Ordnance officers. All the trials are carried out conscientiously, and the figures give, except in cases of special tests, the *normal* performance of the piece tried, according to the programme, which of course, varies with the gun.

As regards exhaustive endurance tests, the Krupp Works are very fortunately situated, as both the quality of the metal and the system of construction have been proved by long experience.

In order to draw entirely fair conclusions, Colonel De la Rocque should compare the most recent type of French guns, with the present Krupp siege and sea-coast ordnance, a homogeneous and well defined system, the details of which will be found in the table on page 91. We cannot better close this review of Colonel De la Rocque's work than by expressing the hope that some day the author will undertake the task hinted at, which is at once worthy of his technical knowledge and literary ability.

CHAPTER III.

The Belgrade Competition.

All who oppose Krupp regard this "Servian matter" with great satisfaction; Colonel De Bange's adherents keep ringing the changes, and gleefully quote favorable newspaper comments, especially those from the French press, at the same time both judge and advocate. As the question hinges on the fact whether the Belgrade trials of 1884 were favorable to Krupp or De Bange, an accurate summary would seem to be in place.

The comparative tests were made near Belgrade in November and December 1884, a Krupp 8.4 cent. gun, a De Bange 8 cent. and an Armstrong 7.5 cent. participating. The tests were of varous kinds.

I—Carriage Tests.

On the 4th and 5th of November, the rival carriages were submitted to march tests. In these trials, the Krupp gun answered all the demands of the programme. "Action front" was executed more easily and more quickly with the Krupp, than with the French gun. The French and English ammunition chests were of old model; as a result, the insecurely packed cartridges, at the conclusion of the test, were found scattered about, a result of the concussions of the march.

During the march, the French gun jumped in an alarming manner; one of the staples of the front carriage transom was broken off, the hub of the right wheel and some of its spokes were loosened, similar evidences of weakness were noticed in the English carriage. The Krupp carriage and gun stood this test without the slightest harm.

II.—Accuracy and Effect of Firing.

The Krupp gun fired in all one hundred and thirty-two rounds, divided as follows:

Series.	Kind of Projectile.	Range in Metres.	Number of Rounds.	Remarks.
I.	Blank shell	1,000	10	
	Loaded shrapnel . .		9	
II.	Loaded shell	1,500	12	
III.	Blank shell	2,000	24	
	Loaded shrapnel . .		9	
IV.	Loaded shell	2,900	12	
V.	Loaded shell . . .	3,500	3	
	Blank shell		10	
VI.	Loaded shell	4,100	13	
VII.	Blank shell	4,100	30	Rapid firing.

The French gun went through the same programme. The Armstrong had to stop after the sixty-fourth round, the fermature housing to which the elevating screw is attached having given way. We now give the details of the practice:

A.—Practice with Blank Shell.

Object aimed at: a vertical target 6 metres square.

First Range, 1,000 metres, November 12th, 1884.

		Krupp.	De Bange.	Armstrong.
		centimetres.	centimetres.	centimetres.
Dispersion.	Vertical	115	200	180
	Horizontal . . .	175	100	135
Mean Deviation.	Vertical	23.0	57.0	32.4
	Horizontal . . .	48.3	25.6	28.0
One-half the hits were grouped in a space on the target.	High . .	38.9	96.1	54.8
	Wide . .	81.6	43.3	47.8

Second Range, 2,000 metres, November 12th, 1884.

On the 12th, the weather was so unfavorable that it interfered seriously with the accuracy of the practice, which was accordingly postponed until the 17th.

Third Range, 2,000 metres, November 17th, 1884.

Object aimed at: as before.

Ten rounds resulted as follows:

		Krupp.	Remarks.
		centimetres.	
Dispersion.	Vertical	470	During this days' practice a mistake occurred, which had its effect upon the firing. The cannoneer used a *coarse* sight; Krupp's representative gave a *fine* sight correction. The results were not so good as were with justice expected of the gun.
	Horizontal . . .	350	
Mean Deviation.	Vertical	47.6	
	Horizontal . . .	83.3	
One-half the hits were grouped in a space on the target.	High . .	198.7	
	Wide . .	140.8	

We have not at hand the corresponding data for the other guns, but we can state that the results were not at all more favorable.

Fourth Range—3,500 metres. *December 2d, 1884.*

Object aimed at: as before.

Three loaded shells were used to determine the distance, given as 3,000 metres, but which was actually 3,500 metres.

a. KRUPP GUN.

Ten shots were grouped between 10 metres in front and 50 metres (average 13 metres) behind, the target; there were six direct hits.

b. DE BANGE GUN.

Ten shots were grouped between 40 metres in front and 100 metres (average 22.5 metres) behind, the target; there was one direct hit.

B.—Practice with loaded shell.

Object aimed at: two targets 20 metres wide by 1.8 metres high, with an interval of 20 metres.

First range—1,500 metres. *November 18th, 1884.*

Number of rounds: 10.	Krupp.	De Bange.	Armstrong.
Total number of hits	400	105	250
Number of hits per round . . .	40	10.5	25

Second Range—2,900 metres. *December 1st, 1884.*

The range was given as 2,500 metres ; it was really 2,900 metres.

Number of rounds: 12.	Krupp.	De Bange.	Armstrong.
Total number of hits	49	3	29
Number of hits per round . . .	4.1	0.25	2.4

Third Range—4,100 metres. *December 3d, 1884.*

The range was given as 3,500 metres ; it was really 4,100 metres.

Number of rounds: 10.	Krupp.	De Bange.
Total number of hits	17	1
Number of hits per round	1.7	0.1

C.—Practice with loaded shrapnel.

Object aimed at: as before.

First Range—1,000 metres. *November 26th, 1884.*

Number of rounds: 9.	Krupp.	De Bange.	Armstrong.
Total number of hits	281	141	342
Number of hits per round . . .	31	16	38

Second Range of 2,000 metres. November 27th, 1884.

Number of rounds: 9.	Krupp.	De Bange.	Armstrong.
Total number of hits	295	129	144
Number of hits per round . .	33	14	16

III.—Rapid Firing.

The programme required the delivery of thirty rounds at close range, without accurate aim, in the shortest possible time. The further condition was imposed that the fermature should not be lubricated or cleaned during the trial.

From the beginning of the test, the Krupp fermature was not carefully closed. At the tenth or eleventh round, Krupp's representative, fearing that this persistent carelessness would have an injurious effect upon the service of the piece, wanted to stop the firing in order to close the wedge securely, but the cannoneer, who did not understand what was wanted, nevertheless pulled the lanyard. During the subsequent rounds, the breech mechanism was properly closed, but the previous neglect had already caused erosions on the gas-check ring, and, in consequence, the fermature became more and more fouled. After the sixteenth round, the wedge stuck; it was loosened from the right and doused with glycerine; thanks to which, it worked well to the end. Another cause of delay was added to this; the cannoneer who fired the piece did not fully enter the primer in the vent, so that in pulling the lanyard, he tore off the branch. It should be stated that this was a new man, who replaced another taken sick, and that this trial was his first service with the piece. All the

primers, including, of course, the one in question, were supplied by the Servian officials and were a part of the old Turkish equipment. The extraction of the broken primer and the clearing of the vent consumed several minutes. Notwithstanding these drawbacks, the gun fired its 30 rounds in 33 minutes. As the failure of the primer could not be attributed to the piece, the Board fixed the official time at 30 minutes. The French gun fired the 30 rounds without interruption in 23 minutes. The erosions already existing at the front end of the vent were considerably extended. We have then in few words the results of these trials.

IV.—Analysis of the Results.

Soon after the test, the gun was examined by an inspector from Essen and it was found that the locking screw was upset, at the end of the threaded part, as well as the breech slot threads.

These injuries could be produced by the cannoneer's not keeping the screw handle horizontal while moving the wedge. The proper position of the handle is very readily fixed by keeping it against the stop on the left. Krupp's opponents declare "that the injuries to the locking screw manifested in the gun were due to the handle's not being kept horizontal, and yet this horizontal position is assured by a spring catch. It is probable that the cannoneer serving the breech, after having pushed the wedge home, forgot, in the excitement of rapid firing, to depress the spring catch, which, when down, prevents the handle from turning, and of course, the breech from opening."

This ingenious hypothesis is open to but one objection, it is altogether wrong, for the *horizontal position* of the handle here referred to characterizes an *open*, and not a *closed* breech. Upon this point Krupp's explana-

tions are surprisingly clear, misapprehension is impossible.

Further, the object of the catch is not, as assumed by our adversaries, to prevent the turning of the handle, or, in other words, to lock the breech in firing; it is merely designed to prevent the wedge's opening on the march. Those who doubt this had better consult the Prussian Field Artillery Instructions of August 23, 1877, page 44, where it is enjoined *not to depress the catch in firing*, an injunction already referred to in the description of the Krupp gun. Hence the explanations offered by the adherents of the De Bange gun to account for the injuries to the Krupp fermature, as well as their commentaries thereon, are entirely without foundation.

It is further worth while to quote the Prussian Instructions upon another point; in them we find the following:

"The gas-plate and rear surface of the gas-check ring should be sponged during the pauses in firing, but this may be done earlier if necessary; but, in all cases, under the special direction of the Chief of piece." Here we have official confirmation of the fact that frequent cleaning of the gas-plate and ring of the Krupp fermature is not essential. Before Russia adopted the Krupp field-gun with cylindro-prismatic wedge and steel gas-check, of the model still in service, there were fired at Essen 500 and 250 rounds respectively from a four and a nine pounder, for the very purpose of testing the gas checking device. During the trial, cleaning was permitted only after every hundred rounds; thus the proof was exhaustive.

At the inspection of the gun used at Belgrade, made by Krupp experts, the injuries to the vent-plug did not appear to have been produced by the rude handling of the wedge, they had more the appearance of hammer marks; the metal was upset on one side as though it

had been driven in by a punch. Indeed, the end of the guiding groove cannot strike the vent-plug unless the wedge be *open; closed*, it is impossible that it should ever come in contact with it. The compression of the metal may in a measure be explained by assuming that the wedge had been pulled out at the moment when the gunner's gimlet was used to clear the vent of the broken primer. Aside from the damage, it is certain that the other three injuries must have existed before the beginning of the rapid firing.

Krupp's opponents allege that it is indeed somewhat astonishing that the Essen representative, Mr. Prehn, the experienced director of the Meppen Firing Ground, had not perceived this abnormal state of affairs before the trial. On the contrary, it seems quite natural to us that these defects should have escaped Mr. Prehn's observation, more easily perhaps, *because never during regular tests at Meppen, or elsewhere, has the Krupp fermature been thus injured.* The only precaution taken before commencing to fire was to ascertain that the gas-check was in good order.

That these injuries existed before the firing seems to be fully established by the fact that already during the first few rounds, the wedge worked stiffly and could not be perfectly locked, and that at about the tenth round the locking screw was engaged very incompletely in its nut.

To recapitulate, the detriment to service which resulted from the imperfect working of the fermature was limited to the fouling and stiff movement of the wedge, to some scoring upon the rear face of the gas-check ring and to a delay of seven minutes, compared with the rival gun, in the rapid firing trial. It is evident that the very same accidents might have happened to the De Bange gun. The safeguards to be observed, according to the French Instructions, in the working of the De Bange

fermature, and the mishaps that occurred with this gun in last year's field manœuvres, are tangible proofs. It is a fact, announced by French journals that on several occasions, imperfectly closed pieces were fired, and that—a graver matter than the fouling and stiff working of the Krupp fermature—cannoneers fell victims to this negligence. These accidents occurred, as we have a right to infer, with well-trained detachments. That it came about that in the Belgrade tests negligence in serving occurred with the Krupp, and not a suspicion of it with the De Bange gun, must probably be ascribed to pure luck. Still this question is not now an important one, for it must be clear to all that if the De Bange gun had been fired at Belgrade with an incompletely closed breech, it would not have completed the test with the comparatively slight delay of the Krupp; indeed, it would not have fired another shot during the trial. We have seen that tho French gun succeeded in delivering 30 rounds in 23 minutes, while the German required, on account of the unusual conditions described, 30 minutes. The triumph of Colonel De Bange was short-lived; upon the request of Krupp, the test was repeated under precisely the same conditions, May 6, 1885, and the 30 rounds were easily fired, as stated in the official report, in 16 minutes.

The results at Belgrade showed that, as regards accuracy, both the Krupp and the De Bange gun did not come up to expectation; but the exceedingly unfavorable weather, and the generally trying conditions under which these trials were carried out, may be offered in explanation of their impaired performance. Yet still, the Krupp gun did better, as might have been foreseen, for the range tables of the two guns would prove to anyone caring to examine them that, under normal conditions, the German gun is superior to the French.

Krupp used with his gun at Belgrade cast-iron ring

shell with percussion fuze, and steel shrapnel with base vent and time fuze. Detailed drawings were furnished the Servian War Department.

The De Bange gun fired during the trial cannister shell, model 1880 (*Cours spécial*, § 22), containing 93 cast-iron bullets in 12 layers, and a shrapnel, the same as used for the 12 and 15.5 cent. guns. (See *Cours spécial*, § 151.) The latter are nothing less than an elongated form of the old spherical case. Both projectiles used the field percussion fuze, (*Cours spécial*, § 28), Colonel De Bange not having at this date a time fuze in his equipment.

In view of the disparity in the technical value of the projectiles used with the guns, the superior effect of the Krupp shrapnel is not surprising. We must admit that lately the French journals have cited instances of extraordinary results obtained with the De Bange projectiles; they may be founded on fact, for progress is not confined to any one country, but before accepting them we must await the details of the trials, the size and number of the targets, the weather and so on, all necessary factors in the formation of a correct and logical conclusion. Keeping in mind these explanations, are we not justified in asking every unprejudiced Ordnance officer whether or no Krupp came out of this singular tournament ahead of his rival De Bange? (1)

V.—The True Inwardness of the Belgrade Competition.

It was a foregone conclusion that, notwithstanding Krupp's success, the Cail Company should receive the contract. The Belgrade experiments had but a single object; they were a species of sop to Cerberus, undertaken to satisfy in a way those Servian officers who wanted Krupp guns for the national armament.

To-day, when the Servian loan negotiated by the

(1) For further particulars regarding the De Bange material in the Servian Service, see Appendix.

Comptoir d'Escompte of Paris, a concern, as is well known, deeply interested in the Cail Works, is an accomplished fact, all doubts are dissipated, and we may well say, it could not have been otherwise. The gist of the matter is this: the forty million franc Servian loan was put on the market at 77, bearing 5 per cent. interest, redeemable at par in 49 years, and guaranteed by the Government Tobacco Monopoly. Among the offsets for its signature, received by Servia, appears at the very head, the De Bange Artillery material. Assuredly the shareholders of the *Comptoir d'Escompte* could not blame their directors for concluding a profitable negotiation, and also endeavoring to share their good fortune with French manufacturing interests; but surely a little more frankness would have been in place, especially now that by degrees the veil is lifted, and the Belgrade tests appear to even the most distant observer in their true light. Surprise is expressed in the De Bange camp that Krupp did not know what the Servian Government was after, when he entered the lists.

It is, however, probable, if not certain, that, at the time, the Servian authorities themselves had not yet taken into account the extent of their future orders; we may positively state, though, that had Krupp known that the *Comptoir d'Escompte* would be the promoter of this loan, and had determined to place the supply of guns with the Cail Works, he would have refused to take part in the competition proposed to him. We would not indulge in such plain statements had we not backing in the opinion of Émile de Laveleye regarding this kind of financial bondage imposed upon Servia. This author, in his striking work, "The Balkan Peninsula" (Muquardt, 1886), writes in these prophetic words: "I read in a financial paper, 'The Berlin press is occupied with the Servian Tobacco Control question. The establishment of this government monopoly is con-

ceded in the preliminary loan negotiations with the *Oesterreichische Laender Bank* and the *Comptoir d'Escompte*. The revenue is fixed for the first five years at 2,250,000 francs, increasing in quinquennial periods, and is pledged in guarantee of a forty million loan. The interest will be paid directly by the holders of the Government Tobacco Monopoly from their receipts." The distinguished political economist adds: "How sad! Here is Servia, just emancipated and numbered among independent States, following the example of Turkey and Egypt. She hypothecates and pledges, by degrees, all her resources, and gives European money-lenders—a far more serious matter—the right of interference in her internal affairs. This ends her independence; she no longer pays tribute at Constantinople, but at Vienna and at Paris, and upon much more onerous conditions. She is striding towards bankruptcy or the financial enslavement of her people."

The vain efforts now making by the Servian Chamber to free the country from the galling yoke of this contract are an exceedingly sad verification of Laveleye's prophecy.

And we are calmly told that under these conditions, indissolubly bound as she is to the Comptoir d'Escompte, Servia, in view of Krupp's success at Belgrade, might have repudiated the obligation to purchase De Bange guns! Nonsense!

A personal explanation to conclude this train of thought: Captain A. Mariotti, author of "French and German guns," finds fault with us because, in an anonymously published report of the Belgrade tests, we quoted Lieutenant-Colonel Muellertz, a retired Danish Artillery officer, in favor of the Krupp system.

"This," says our critic, "is open to suspicion, for Colonel Muellertz is at present Krupp's agent for Nor-

way, Sweden and Denmark." We candidly confess that, while we were not aware of this fact, had we known it, we would still have attached as much weight to the opinion of this "honorable officer of rank," as Captain Mariotti calls him, as to that of Colonel Gjertsen, Captain Mariotti's father-in-law and the Norway agent of the *Société anonyme des anciens établissements Cail* (General Manager—De Bange). Both wore the uniform, and that satisfies us. But let us once for all abandon this method of discussion, unworthy of the pen of Captain Mariotti or any other officer.

CHAPTER IV.

Last Words.

We cannot close this discussion without pointing out to our readers the weakness of the arguments advanced by the author of "*Canons frangias et allemands*," or without adding a word concerning Lieutenant Colonel Hennebert's exceedingly bitter pamphlet, "*L'artillerie Krupp et l'artillerie De Bange.*

Captain Mariotti, like most others who write in Colonel De Bange's interest, denies that there is a "Krupp metal," though he enumerates, among the various processes of making steel, the crucible method. But every one knows that "Krupp metal" is simply a special variety of crucible steel made at Essen, and it is generally acknowledged that Krupp, who began making steel guns when the rest of the world confined itself to bronze and cast-iron, deserves the credit of inaugurating this radical change in gun-construction. It is an open fact that all Ordnance authorities, including the French, in taking action upon this new departure, largely availed themselves of Krupp's experience. This is in brief the history of the development of steel gun fabrication.

Captain Mariotti has then undertaken an unwelcome task in trying to deprive Krupp of this proper priority, and is unfortunate in basing his proof upon inexact quotations from a German authoritative work, Major Mueller's "*Entwickelung der Feld-Artillerie.*" The reader can attach his own value to Captain Mariotti's assertions, after comparing the following passages: one, the French author's; the other, a literal translation of the same German text.

In "*Canons frangais et allemands,*" we read: "Un-

fortunately, in 1865, some 8 cent. guns (Model 1864) burst without discoverable cause; similar and more numerous casualties occurred during the campaign of 1866, and these accidents had a most unhappy effect upon the *morale* of the troops, as they lost confidence in their material. It was at first thought that these mishaps, in part at least, were due to the method of closure, and modifications were made which led to the model of 1867. 'However,' says Major Mueller, 'it was not an easy task to do away, by means of purely theoretical arguments, with the mistrust that had arisen against the use of steel. This feeling was intensified by reports received from the officers in charge of construction. Having had an extended tour of duty at the Krupp Works, they were thoroughly familiar with the Essen methods, and yet they doubted the uniformity of the output.'

"According to these officers, each steel gun had its individual qualities, and results obtained with one were not necessarily applicable to other guns. The Ordnance Corps, in deference to this unanimous expression of opinion, was compelled to fall back upon bronze constructions, and, towards the end of 1869, the Prussian Government placed a large order for 8 cent. bronze guns, intended for the reserve batteries. These pieces appeared but in small numbers upon the battle-fields of 1870-71. They did well; yet it was observed that under fire they deteriorated more rapidly than the steel guns. The steel guns of the divisional batteries, which it was impracticable to replace, gave proof of excellent qualities (except as to the mishaps, to be discussed in the next chapter), and restored confidence in the use of this metal."

The accidents to Krupp guns, of which Captain Mariotti speaks, are thus described by him: "Surely the same thing could not be said of the Krupp guns,

which, according to the papers, have burst, not during experimental firing or with increased charges. Even admitting that these press reports are incomplete or inaccurate, and that the writers, unfamiliar with technical terms, call accidents resulting from the awkwardness or negligence of gunners, 'bursts,' yet many of these guns must have actually burst during field-firing, for the German accounts of the war of 1870–1871 make mention of a large number of pieces rendered unserviceable by their own fire. At Rézonville and Saint-Privat especially, a number of Prussian guns were compelled after some rounds to cease firing. * * *

On May 15th, 1875, Major Haig stated before the Royal Artillery Institution that *two hundred* guns had been rendered unserviceable during the Franco-German war ; a statement confirmed by Krupp in a letter sent to *Engineering*." *

It appears then from this summary of facts which the author of "*Canons français et allemands*" declares to have drawn from Major Mueller's work, that this field officer of the German Ordnance, announced himself in 1873 as opposed to the use of Krupp cast-steel.

Here is, word for word, what Major Mueller *does* write :

" In 1865, and during the war of 1866, some of the 8 cent. guns with the wedge fermature adopted in 1864, burst without previous warning, and without a visible defect in the metal. There did not seem to exist a positive guarantee of the strength of the steel ; at any moment, similar accidents might happen. This possibility exerted an unhappy influence upon the battery, which lost confidence in its weapon. An exhaustive examination of the subject led to the conclusion, especially in view of the fact that not a single 9 cent. gun with bolt fermature had burst ; that the accidents were due

* See Appendix.

not to the quality of the metal, but to the defective construction of the breech slot.

As a result, this was modified about 1867, and no further mishaps, not even during the war of 1870-71, occurred. Still, this theoretical explanation could not at once overcome the distrust felt against steel. In fact, it increased, when the reports of officers stationed at Essen, upon the fabrication of cast-steel, were received. These officers had had opportunities of observing the details of the process, and doubted the uniformity of method, so that each gun had to be considered as a unit, whose behavior did not necessarily indicate what that of others would be.

The Ordnance Corps, which was in duty bound not to incur the slightest risk, deemed it expedient to design and to order bronze guns.

The Ordnance Board was directed at the beginning of October, 1866, to consider the construction of a 9 cent. bronze rifle, to weigh not more than the steel gun, and to fit the model 1864 carriage. * * * After these results, some few further details of construction were determined upon, and thereupon, at the end of 1869, with the Royal sanction, a larger number of 8 cent. bronze guns were ordered. For the present, these guns were not to be assigned to field batteries, but only to the foot batteries of the reserve.

A number of the Prussian 8 cent. bronze guns were used, though upon a restricted scale, during the war of 1870–71, and no special shortcomings were observed. But further trials have shown that the bronze pieces enlarge very rapidly in firing, and therefore lose their accuracy much sooner than steel guns. This, in conjunction with the fact that *the steel guns brought about the great success of the war*, that they on occasions fired very many rounds without decrease of accuracy, and that *not a single one burst*, completely restored confidence

in cast-steel, and led to a just appreciation of its merits. It cannot be denied that bronze guns subjected to the same hardships would not have endured as well, would have deteriorated in accuracy, and would have had much less effect. *Cast-steel has on this account won the victory, not only in Prussia, but in most States where bronze was still used.*" Captain Mariotti has either not comprehended Major Mueller's thought or he has used—of course without knowing it—a translation colored to suit the interest he defends ; for it is now clear to every reader that the opinions ascribed to Major Mueller are in direct opposition to those advanced in his work. There is no justification for that species of argument which consists in taking a phrase here and there from the author's work at the risk of giving a false impression as to his opinions, and every impartial observer must share our view, that a theme which requires such means of defense must indeed be in desperate straits. We accordingly believe that the comparison of the French author's text with the real text of Major Mueller is sufficient rebuke to Captain Mariotti, without further comment on our part.

We shall not here revert to the mishaps charged to Krupp guns, and catalogued with relish by Captain Mariotti ; we have already met these imputations, which, though the author may change, always remain the same. Besides, the major part of the allegations are drawn from Lieutenant Colonel De la Rocque's book, and have already been answered. Our adversary, however, following the lead of most of the De Bange adherents, is careful not to cite the authority from which he draws so copiously. This timidity is rather easily understood, when we recall that Lieutenant-Colonel De la Rocque is not an enthusiastic advocate of the use of Martin-Siemens steel. Indeed this outspoken, well-posted officer is too doubtful an ally to bring his in-

vestigations to the notice of believers in crucible steel. Captain Mariotti seems, however, to have had qualms of conscience, as he cites Colonel De la Rocque to show the rigorous restrictions governing entrance to the Essen Works. Availing himself of this officer's pamphlet, "*Les principales artilleries de l'Europe, d'après la commission spéciale des Etats-Unis,*" he gives an extract from a communication addressed by Krupp to the President of the Gun Foundry Board, which is thus translated by Colonel De la Rocque: "The Works at Essen cannot be seen, as these are closed even to those who have special business of inspection of war material on order." We deemed it worth while to look up the *original* letter (Appendix Q, Report of Gun Foundry Board), and here reproduce the passage:

"The Works at Essen cannot be seen, as these are closed to all but those who have special business of inspection of war material on order." It does not require a very profound knowledge of the language of Shakespeare and Milton to convince one's self that this means; "The Works at Essen cannot be seen, as they are closed to all *excepting* those etc."

As is seen, Colonel De la Rocque makes the Essen constructor say just *the opposite* of what he wrote to the Board. It is not a matter of wonder, then, to find, in French writings, extracts from English and also German authors condemning the Krupp system, or the Essen methods; to reach this result, it is only necessary to misinterpret or to mistranslate. Before finishing with Captain Mariotti's work, we feel it necessary to express an opinion upon a matter made very prominent in his argument. We refer to the fact, that recently Krupp furnished Norway, for experimental trials about to take place, two field-pieces with De Bange fermature.

Captain Mariotti denies that there is the slightest commercial justification for such action, and asserts that

French makers would never attempt to imitate Krupp's designs, though they could do so with the greatest ease. Krupp's adherents are taunted by the author with being compelled, after their enforced acknowledgement of the superiority of the De Bange constructions, to have recourse to the fiction of a " Krupp metal " to save the reputation of the German guns.

We have already shown what there is in " Krupp metal " ; our position in this respect is not a new one, it goes back to the first steel gun ever made. As to breech mechanism, we are convinced, as are the vast majority of artillerists, that the Krupp fermature, even for field guns, is superior to the De Bange, and we have already given the reasons. Still it must be kept in mind that the De Bange fermature is something new, and possesses qualities well adapted *at first sight* to engage the attention of Ordnance Officers, so that prejudice in its favor, though it be but fleeting, is not hard to explain. We think there is no reason why the Krupp Works should be blind to this, or why they should decline to furnish the De Bange fermature *upon a Government order*. No patent rights are infringed, and as to consideration for the brain-work of the inventor, it is undeniable that the De Bange fermature is the direct offspring of the designs and investigations of Treville de Beaulieu, Reffye, and Montluisant. (1) Besides, Colonel De Bange has no scruples in following Krupp models when the occasion arises. It is established that the gun-carriages, limbers, etc., furnished Servia by the Cail Works, are exact copies, except as to some details, of the Krupp constructions, which the French experts had abundant opportunity of examining at Belgrade. Captain Mariotti, it appears to us, has hardly acted wisely in reproaching Krupp for doing what his French competitor practises on an extended scale and without the least compunction.

(1) See in this connection Benjamen Chambers' (of Washington D. C.) patent of July 31st, 1849. (O. E. M.)

Lieutenant-Colonel Hennebert's pamphlet contains no important fact which we have not already discussed, only the mode of presentation varies. More than all its predecessors, it is characterized by an indisputable spirit of dislike and unfairness to the Krupp Works. Of course, up to a certain point, we can understand that France feels humiliated in not being able to overcome Krupp's acknowledged superiority in gun fabrication, but we candidly ask the author, "Can you gain well-wishers for French manufacturing interests by presenting the actual state of affairs in a light entirely different from that accepted as true by everybody else?"

Thus, Col. Hennebert asserts that the Krupp establishment is subsidized by the German Government; of course, the object of this is plain: it is intended to show that French industry copes on *altogether unequal* conditions with Krupp.

Any one at all acquainted with financial or commercial matters, leaving officers out of account, knows that the Essen Works are the exclusive property of Mr. Alfred Krupp, and that, since the repayment of the loan openly negotiated about ten years ago, the owner operates entirely with his own capital. It is, therefore, somewhat surprising to find in serious writing such comicalities as the following: "Everybody knows that the German Emperor, the Imperial family, all the important Court functionaries and Prince Bismarck, are (without exception) stockholders in the celebrated plant on the banks of the Ruhr."

"The German Government has granted Krupp a subsidy of 1,500,000 francs to enable him to submit bids *even at a loss*, and thus to maintain his supremacy in the fabrication of ordnance material." * * "Krupp has opened a credit of 100 millions in favor of the smaller Eastern Powers, who are at present in financial straits."

It is possible such flights of imagination may be acceptable to French readers ; but, of course, no unprejudiced person would regard them as possessing any weight whatever. Lieutenant-Colonel Hennebert also harps upon the Belgrade competitive trial, and treats the matter from a stand-point that compels us to refuse to follow his lead.

Under this heading there are rumors of "*insinuations of conduct to which Krupp had not feared to be led*, and which affected the honor and standing of various personages." There is mention of "bribes, which, *according to Krupp*, the Cail Works had offered the Servian Commissioners," all, of course, entirely unknown to the great gunmaker, and unworthy a place in the discussion of so elevated a theme. We feel it a duty to affirm that such methods of discussion detract greatly from the interest taken in the Cail Works—interest due not only to the General Manager's efforts in furthering ballistic progress, but also to his struggle against the powerful competition of Krupp. Such arguments destroy the cause they are intended to serve. After what we have said it can readily be understood why Krupp has not taken up the gauntlet thrown down by Colonel De Bange, to try anew conclusions between guns made at Grenelle and at Essen. Such a competitive test would at best be fruitless, for the decision of the most important questions would necessarily be beyond its scope. The past history of Krupp guns is an assurance of their future.

Conclusions.

Having arrived at the end of this comparative investigation, we think it best to summarize the conclusions reached :

I.—The Krupp construction is the result of elaborate investigation, and provides especially, in all calibres, for

the thorough absorption of longitudinal strain, while Colonel De Bange's double taper hooping does not meet this requirement, and leads only to erroneous estimates of the strength of the gun.

II.—The wedge, owing to its elastic action, offers a perfect safeguard against unbreeching, while the screw acts directly and suddenly upon the metal, and the slot threads are actual inducements to rupture.

III.—The Broadwell ring has been tested in all the Krupp guns, and under all pressures; it is the same for all calibres. The plastic gas-check of De Bange though it may have been tested successfully up to a certain point in medium calibres, is of doubtful efficacy with large calibres, a doubt corroborated by the necessity of using two concentric packing pads.

IV.—Taken altogether, the Krupp fermature is simpler than the De Bange; its working is easier and surer.

V.—The finishing and fitting of the De Bange guns are inferior to the mechanical work of the Krupp, of which all parts, to the minutest details, have been evolved with thought and care after exhaustive trial.

VI.—The *practical* value and the endurance of the De Bange guns have not yet been put to the test of a single campaign worthy of the name: for, of course, the experience gained in the Tunis and Tonquin expeditions is not sufficient for the formation of correct conclusions; on the other hand, the ballistic advantages, the facile manipulation, and the service life of Krupp guns have been strikingly proved in every important war of the last quarter of a century.

VII.—The ballistic effect and accuracy of the De Bange field, siege and position guns are inferior to those of the Krupp. In large calibres there does not

exist a *single practically tested* De Bange gun which can be pitted against Krupp's heavy guns, of great power and accuracy, and which have been supplied to nearly all States.

VIII.—Krupp Crucible steel meets the requirement of homogeneity, an *indispensable* quality of gun metal, which the Open-hearth steel used for De Bange guns does not always possess.

PART THIRD.

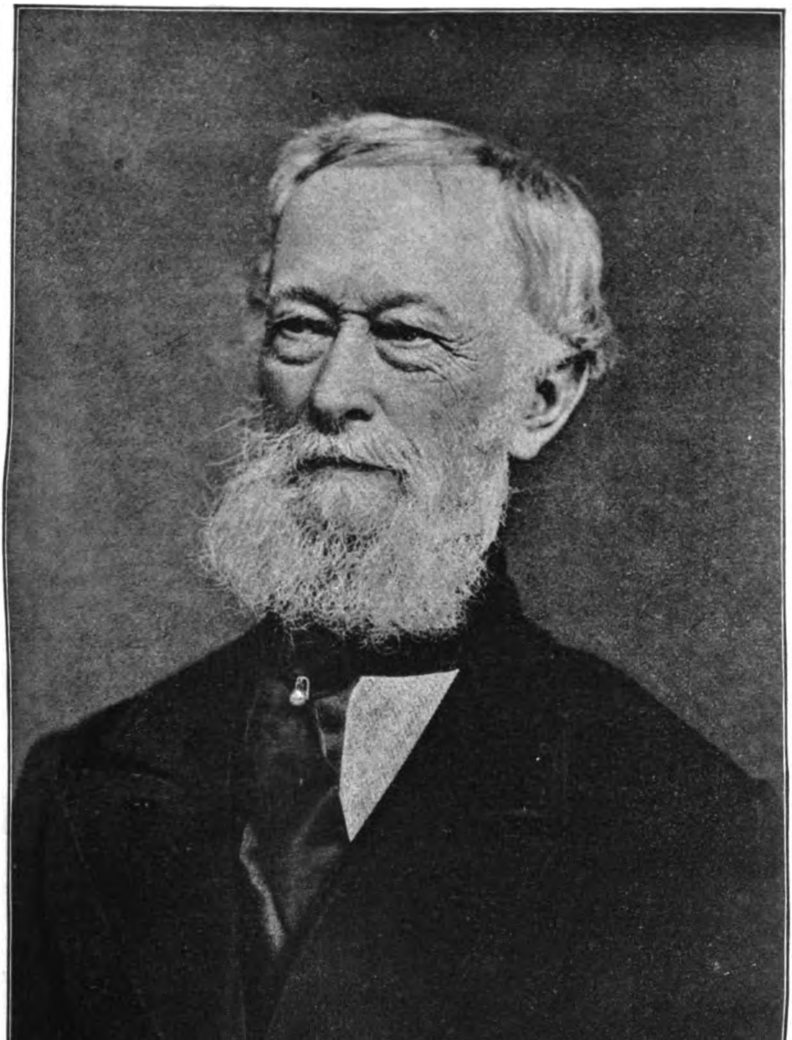
A visit to the Krupp Works.

If we have been fortunate enough to retain our readers' interest thus far, we will invite them to visit with us the great Krupp Works at Essen, which are so justly entitled to be called the pride of Germany.

I.—Essen.

The city of Essen lies north-east of Dusseldorf, and is reached from Brussels by way either of Cologne or of Gladbach. It is situated in the fertile basin of the Ruhr, near Duisburg, another manufacturing city. Indeed, Essen is in the centre of the great factory district of Westphalia, a veritable hive of industry, in which are also to be found, Crefeld, Elberfeld, and Dortmund. These are not the only noticeable features of Essen's position, for it lies in one of those fortunate regions in which Nature has stored abundant coal and iron, the very bases of metal working.

To the Krupp Works Essen owes its world-wide reputation, and in a great measure, all its prosperity. In 1862, its population scarcely reached seventeen thousand, but the number of workmen employed in the great foundry increasing from day to day, the little town did not cover sufficient ground to shelter them all, and rapidly expanded. In ten years the population doubled, and to-day, encircled by a belt of attractive suburbs, the old city contains nearly one hundred thousand people. The impression is at once received that the whole town is more or less dependent upon the Works.



Alfred Krupp.

Let us stand at about noon near the Mills, on the Essen and Duisburg turnpike which traverses them; at the twelfth stroke, the gates open, a flood of workers issues, and scattering, flows towards the comfortable, well-drained houses, which Krupp's fatherly interest in his people has provided at moderate rentals.

When the bell recalls to work, the city resumes its medieval calm, and retains it until evening, when again the mighty multitude overflows its streets.

II.—Turgan's Pamphlet.

Turgan, who published in 1865 a description of the Krupp Works, as far as we know, the only one up to the present time, relates that he experienced a singular sensation when awakened in the early morning by the footfalls of the men silently marching to their work. "The Germans on this side of the Rhine," the French writer tells us, "either have little to say, or talk in very low tones."

We were impressed in the same way, and, had our attention not been called to the fact, we should have thought of the still, impressive marching-by of an army. As we have mentioned Turgan, we may say that in many points his description applies to-day; we have verified his statements step by step. His account of the fabrication of crucible steel is still, in the main, accurate. Of course it is hardly necessary to state that since 1865 every improvement, the result of scientific investigation or practical experience, has been introduced. Bessemer converters and Martin-Siemens furnaces are used in making commercial brands of steel, but—to us the cardinal, the essential point—for gun-metal, crucible steel *alone* is used, a steel produced here for over half a century, and to which the establishment owes its success.

III.—First Impressions.

The Krupp establishment at Essen occupies about 1,000 acres, of which nearly 200 are under roof. Let the reader endeavor to realize what this really means. The buildings run north and south of the Dortmund and Duisburg turnpike. On approaching from the town, these rows of shops present an imposing sight; fifty, sixty, possibly more, structures, whose high chimneys or rather towers, are continually pouring forth showers of sparks, or thick clouds of smoke, the ponderous booming of the steam hammers, the loud humming of the engines, the signal whistles of the locomotives, laboring and puffing under their heavy loads, the black bulk of the enormous bulging gasholders for lighting the Works, all appear to be the embodiment of wonderful force and power, and bring up a vivid image of the man who, actuated by a determination as unbending as iron, a persistence as strong as steel, created this Temple of Work.

IV.—The Entrance.

Here we are at the Works; the gates do not open for every caller, everybody knows that. Admission is positively refused to all metal makers or workers, these must tarry in the reception room. This prohibition is not due altogether to a useless desire for mystery, still there are processes, the results of several generations of experience, which are kept secret. Were all admitted, the crowds of sight-seers, who would be attracted by the great reputation of the Essen Works, would require an army of guides to conduct them through the labyrinth of shops. The attention of workmen would be diverted, the prompt handling of huge masses of metal would be delayed. Such continual interruptions would be a great nuisance, certainly causing loss of time and money, without the slightest return, for Krupp's reputation is made. As to

interested visitors, manufacturers, scientific and practical experts, etc., it certainly would be the height of folly to permit them to wander at will all over the Works, and study at leisure the thousand peculiar details in vogue, any one of which may for the moment assure especial advantage. Whatever may be said, we regard the experience gained in a life-time of incessant work and unparalleled activity such as Krupp's, as a precious possession, whose influence outweighs all else in the daily improvement of manufacturing methods.

To allow the keen glances of rival manufacturers an opportunity of noting and appropriating the fruits of such life-long labors and experience, would be silly and weak, and against the interests of thousands who are dependent upon the Works for their living. It would be a voluntary cession of all rights.

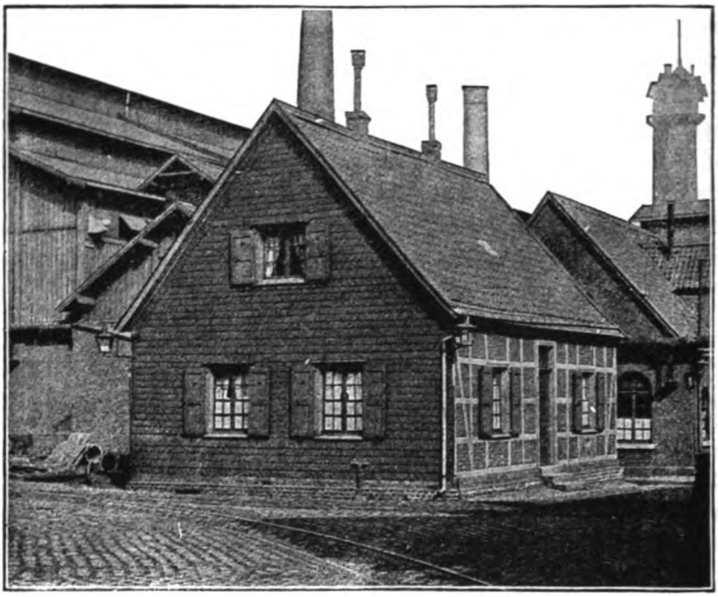
V.—The Office and Krupp's Cottage.

But a truce to these prefatory comments, let us enter. The gatekeeper, one of a number, whose long uniform overcoat suggests the old soldier, eyes us as keenly as a customs inspector scrutinizes a passenger suspected of smuggling; we make no sign, however, and as we are under proper guidance, Cerberus hides his tusks.

This great building which first meets our view is the Office, where a regiment of accountants pass their days in keeping the books of the great firm.

Here is entered everything that goes out and comes in, here are kept the accounts of the States dealing with the Works. We felt a longing to peep, were it but for an instant, into the great ledger, whose contents must be exceedingly interesting, but we did not seek to indulge our indiscreet curiosity; besides we had so much to learn that we did not dare jeoparding, for the gratification of an idle whim, futher opportunity of gaining information.

Close to this brick structure, there is a cottage, such a one as Jean Jacques Rousseau sighs for, with green blinds, small square lights and clean white window curtains; it is pretty and attractive, and had not a locomotive, drawing iron laden cars, rudely interrupted our train of thought, we should for the moment have believed ourselves rusticating amid Swiss mountains.



In this little house, the father of the present proprietor passed his life in making the incomparable steel which has made the Works to-day famous.*

He was not spared to see the full fruition of his life-work, but the tool which his aged hand could no longer wield, was firmly grasped by his son. With the help of a few mechanics, he set to work, by his perseverance he conquered all difficulties—the result is known.

* See note on page 166.

This humble cot, almost lost amidst its towering surroundings, has been kept as an experimental laboratory, and here Krupp's son works daily; it is the family talisman, and the recollections which it calls into life make up the history of two generations, devoted to labor and to duty.

VI.—The Gun Shops.

Our obliging guide takes us first of all to the gun shops; we enter an immense roofed space, we must apologize for the frequent use of this adjective, but it alone, is descriptive—where about one hundred Krupp field-guns are receiving their final touches.

These little playthings, so neat, so pretty that one feels like using them for watch charms, are for his Highness the Sultan of Turkey. He seems to be in a hurry for them, as they are in hand day and night.

We enter a second shop, then a third, both of colossal dimensions; in one, the guns are turned, in the other, bored; here, grooves are cut, there, the breech mechanisms are constructed.

We will not dwell upon this phase of our visit, for though we saw the many operations necessary to convert the unfinished tube with its mantle and hoops into a gun, yet in the main they are similar to those pursued in other gun factories. Only, here, the work is done on a grander scale. As elsewhere, great lathes turn with ponderous dignity, fleet pulleys whirr on their shafts, metal parts groan under the biting of smoothing files; here, however, the hundreds of lathes, the thousands of pulleys, and the steel fashioned by numberless tools, constitute a grand orchestra, ever performing the impressive symphony of Work.

VII.—The Four 120-ton Guns.

In an adjoining shop, the great guns are majestically enthroned; the Leviathans of naval armament, the Behemoths of coast defense. Man feels his insignificance in the presence of these awe-inspiring engines, yet he is their lord and master. Among all these finished masses of pure steel, at whose sides a horde of mechanics are busy, four especially rivet the attention of the beholder; they are the 40 cent. guns, 14 metres long, and weighing the trifle of 120 tons, say one hundred and twenty thousand kilograms! And yet but a few years ago, the 100-ton iron gun with steel lining, made by Sir William Armstrong for the "*Duilio*," was emphatically announced as the supreme effort in the struggle of ordnance against armor, the final outcome of constructive ability! Here the metal is not iron, but steel entirely, and crucible steel at that. The charge of each crucible is only 40 kilograms, and the reader can picture to himself the amount of work embodied in each of these pieces, in remembering that the casting of each involves the simultaneous pouring of from 1,700 to 1,800 crucibles, yielding an ingot of 70,000 kilograms. As each gun consists of tube, mantle and rings, this Titanic operation must be repeated twice for each piece, as the rings alone permit the use of much smaller ingots. The ponderous blocks of steel required for these enormous guns are nevertheless forged and finished with comparative ease, so great is the capacity of Krupp's tools and so daring the intelligence which directs them.

These guns were ordered by the Italian Government for sea-coast defense. *

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*Two of these guns are now embarking at Antwerp for Spezia, their destination. The others will presently follow by the same route.

The press questioned the practicability of transporting these ponderous and unwieldy productions, and asserted that the rails would give under the weight of so exceptional a load. But the problem was readily solved by Krupp's engineers; a platform car was constructed, running on thirty-two wheels with independent axles, so arranged that the whole weight was equally distributed upon all the wheel bases.

VIII.—The Carriage Assembling Shop.

We regretfully left this interesting sight to enter another structure in which are the assembling shops for naval and sea-coast carriages. Communicating galleries are built at a height of 10 metres between the shops. From one of these we glanced above us at the traveling cranes of 50,000, and 30,000 kilograms' capacity, which, at a height of 15, and with a span of 22, metres, traverse the great shops, lifting and shifting the heaviest masses, working automatically by bell signals.

Below us we see in hand a carriage with rotating platform protected by a sheet steel cupola. This model is designed for a great ironclad, the pride of modern navies. Other carriages, of established model, with hydraulic buffers and shot-cranes are ready for the cars, for the track that serves the Works and connects with the Government Railroad system, begins at these shops, and is thus a terminus of the main lines.

Let us go down to get a nearer view of the work of assembling; let us see how the cupola turns on its rollers. Stop, it is moving. "She doesn't work badly," said the foreman, "a little filing here and there, and she's all right." Above us the crane advances, goes back with impressive deliberation, making nothing of its huge loads, and, from time to time, the click of gearing and the ringing of a small bell reveals the existence of the

train that moves this indispensable apparatus; and everything goes apparently in a routine way, quietly, without excitement or shouting; little is said in the Krupp establishment, but the work goes on all the time. At the four corners of the edifice, ponderous lifts are installed, and taken all in all, we are sure that there could not be a better disposition of the powerful mechanical devices with science has placed in the hands of the constructor. But let us hasten to examine the various processes of steel making in use here, for the Essen Works turn out Bessemer, Open-hearth, Puddled and Crucible steel.

IX.—The Bessemer Plant.

Bessemer steel is made on a great scale at Essen, ten thousand tons of rails can be made per month. This shows that Krupp is not unwilling to take advantage of scientific progress, in whatever direction it trends, and does not disdain to make cheap steel to meet the wants of all railroad interests. But we must make no mistake; he uses the Bessemer process only for making commercial brands.

Interested parties have started a rumor that the crucible steel which alone is used for gun-metal, is made in part by remelting Bessemer scrap. We have assured ourselves by watching the charging of crucibles that this rumor is entirely baseless. It would be still more audacious to assert that the converters furnish the ingots required for tubes, mantles or even rings, for we looked in vain for moulds at the Bessemer Works of sufficient size for the purpose, or for cranes powerful enough to handle the great blocks out of which the gun parts are fashioned. The fact is apparent that the Works are especially equipped for the output of the small ingots required in rail fabrication. The Bessemer process is so

well known, even taking into account the most recent improvements, that it would be a thankless task to attempt a description here: whoever has seen it in operation must recall the absorbed interest with which he watched it; the gorgeous pyrotechnic display of "blowing off," the silvery sheen of the sheet of living steel flowing from the converter's mouth amid a scintillating halo into the devouring maw of the charging ladle. Once seen, this fairylike spectacle can never be forgotten.

We witnessed every detail of rail fabrication, from the billets' leaving the heating furnace to undergo transformation in the roll trains, to the last mechanical operations, cutting to length and straightening.

We think that, in this manufacture, our own makers are not behind Krupp, and that they do the work just as well, and as economically. But the old saw, "Shoemaker, stick to your last," comes to mind, let us stop talking of rails, concerning which we have nothing new to say.

X.—The Open-hearth Plant.

Krupp also makes steel by the Martin-Siemens process, which besides affording facilities for determining the character of the bath by the drawing of test specimens, yields a more constant and homogeneous product than the Bessemer. It is slower, we must admit, but it is more certain; the carbon point can be so regulated that we can obtain the hardest as well as the softest metal, steel suitable for springs or for boiler plates. The open-hearth plant is extensive and well arranged. The reverberatory furnaces, in which the molten metal simmers under the action of the flame, are arranged in two rows, having between them cranes of medium capacity; under these are the casting pits. Here, as at the Bessemer plant, there is no sign that open-hearth steel

is used for gun-metal; no deep pits, no gigantic cranes. Not a particle of this steel goes into the crucibles, we assert this without fear of denial, for we have at hand convincing evidence.

Open-hearth steel is used at Essen for the fabrication of all kinds of plate, tires, axles, and other structural parts; also for all castings, such as car-wheels, cross-heads, hydraulic cylinders, and in general for all machine members which do not need that absolute homogeneity and exceptional strength demanded by gun-metal, and which so especially characterize crucible steel. As we entered the foundry, the work was in full swing; the furnaces flamed with dull crackling, and the crane moved along the great bay holding suspended the pouring ladle: at intervals, when above a mould, a stream of molten metal gushed out, momentarily as with a lightning flash making darkness visible, and disappeared in the glowing receptacle. In front of the Works, numerous castings, just from the moulds, were slowly cooling under slag; they were truck wheels. These castings are not to be trusted, inoffensive as they look; they remain hot for a long time, and those who walk about carelessly, are apt to carry away ardent and lasting reminders.

XI.—Krupp Gun Metal.
The Puddled Steel Plant.

It is easily understood that the portion of the establishment devoted to crucible steel making, the metal of which all Krupp guns are constructed, possessed the greatest attraction for us. Besides, with or without reason, all sorts of myths attached themselves to this mysterious metal, and the probabilities are that had the famous gun maker lived in the dark ages, his unlucky competitors would have accused him of witchcraft, and the stake would have effectually disposed of an inconvenient rival.

We were anxious, as was natural, to clear up the mystery; and we had been promised help. Further, we had resolved to keep as "wide awake" as possible. As the result of this somewhat underhanded investigation, we are convinced that it is impossible to find a method of making gun-metal upon a more scientific basis, or one more exactly carried out; everything is designed and regulated for the purpose of producing a steel which chemically and physically is able to cope with the most powerful powder efforts.

The iron ores used by Krupp in the fabrication of his gun-metal, are of the very highest grade and of remarkable purity. As a rule hematite and spathic ores are used, the same ores from which that excellent cast-iron, called by Germans *spiegeleisen* and by the French *fonte miroitante*, is made. They come either from the Siegen region, or from the firm's mines near Bilboa in Spain.

The iron is delivered at the Works in pigs, and makes up the charge of the puddling furnace. The puddling is under control of experienced and tried workmen; indeed a regular puddling school exists at Essen; no one can become a boss until, after numerous and difficult trials, he has proved himself thoroughly up in all the details of the art. Of course, puddled steel is made at Essen upon the same scientific principles as in England, France, or Belgium. While *science* is the same everywhere, each mill has its own special "knack" which characterizes its output. We will go a step beyond, and affirm that were Krupp to establish Works in some foreign country, without taking with him his mechanics, his ordnance experts, and his foremen, many of them men born within sight of his establishment, most of whom have grown gray in his service, the steel he would there make, would be different from that produced to-day at Essen. The determining conditions are indigenous to the soil, and

dependent upon the generations of workmen evolved under their influence, just as the tree clings by its roots to its mother earth.

Let us however return to the iron about to be partially decarburized in the furnace. It is vigorously assailed by the fire, and thoroughly rabbled by the puddler; the excess of carbon is driven off, and the iron becomes steel.

The skill of the puddler lies in stopping the operation at the exact moment when the iron comes to nature; if this passes, the work is lost. The loop, or ball, as the spongy steel mass is called, is carried on a trolley to the steam hammer; the metal is squeezed under its blows, and slag and other impurities are expelled, the molecules are condensed, arranged, and rammed together, and the ball becomes a billet. This hammered billet is then taken to the rolls, and leaves them as a long square rod, which is at once hardened in a pool occupying the centre of the mill. Each rod, after critical inspection as to quality, is broken into pieces about 20 centimetres long, which are sorted accordingly. The toughest and most homogeneous are reserved for gun-metal charges; the others are classed for special work, such as crank-shafts, axles, high grade tires, &c. The advantage of this procedure is self-evident; the expert can, so to speak, after the crucible charge has been fixed, determine beforehand the strength which the melt will possess, and as it is worked in small masses, there is the greatest possible chance of securing almost perfect compactness.

The puddling Works always present a busy appearance; the steel bubbling in the furnaces is energetically stirred and worked by the rabbles of the puddlers; these are fine fellows, all nerve and muscle, whose perspiring faces, occasionally lighted up by a sudden flash of flame, bear testimony to the hardships of their trade.

Here the steam hammers angrily pound the unwilling

billets, further along, the glowing bars writhe in audible agony through the roll grooves. Add to this the whirring of the pulleys, the clanking of the chains which hold the roll tongs, that guide the heavy masses of steel, the calls of the bosses, the chant of the hundred ovens in which iron and coal crackle, the heavy puffing of the steam motors, and you have a picture in ever varying colors of one of the most magnificent phases of modern industry.

Puddled steel, which by the very principle and method of its fabrication, is assured great uniformity, is the base of the crucible charge; the rest of the alloy is puddled iron. This is made of special pigs and worked in the manner just described; it gives tenacity to the compound. It is rather refractory, but then the puddled steel, the greatest part of the charge, has a comparatively low melting point, and a certain flux, one of Krupp's "secrets," is added. We came to the conclusion that charccal was its main ingredient. The crucible, whose contents weigh exactly 40 kilograms, is carefully luted, heated in the warming oven, and is then exposed to the high temperature of the melting furnace.

XII.—Crucible Manufacture.

This is the proper time to speak of the melting pot, the crucible.

It is made of a special composition, peculiar to the Krupp Works.

We witnessed the manufacture, and came to the conclusion that the mixture consisted mainly of fire-clay with a less proportion of graphite.

The material of which the crucible is made exercises a great influence upon the final constitution of the melted contents. Krupp has made this a subject of exhaustive investigation, for the Works consume an enormous

number of crucibles, as each can be used but once. No further evidence of this is needed than the piles of charred and broken pots stacked in the shop yards.

A part of this waste material however is utilized; it is ground into powder under huge vertical stones, and is thus rendered fit for use in making new crucibles. New composition and old dust are ground fine, mixed in great vats, and thoroughly worked up with the utmost care into a thick pasty slip. The crucible is now to be moulded.

Imagine a hollow cast-iron truncated cone, the mould, and a solid metal core of suitable size and similar shape, which fit to just the dimensions of the prescribed crucible. Now fill the mould with the proper quantity of slip and slowly enter the core; the compressed plastic material flows between mold and core and shapes itself; the excess seeks to escape, but is held in by a collar and forms the rim. The pot is then taken out of the mould and dried.

The Works as already stated, consume daily a very large number of crucibles, for as a rule, four crucible casts are made every twenty-four hours. The drying and storing rooms are in immense four-story edifices with spaced flooring on which the crucibles stand in long rows. The Superintendent of this important branch told us that there were always one hundred thousand crucibles in store, which are used in succession. We could not verify this statement, but we are sure that it would have taken us hours, possibly a whole day, to count them.

XIII.—The Crucible Steel Plant.
Casting.

We come now to crucible casting, which in every way is the most singular, the most interesting, and the most picturesque work we saw during our whole visit. The

foundry stretches out almost interminably, and is furnished with all the apparatus necessary for the successful carrying out of this delicate and difficult work. Upon the extended sides, along the walls, are installed the gas heating-ovens; parallel to them in two lines are built the melting-ovens flush with the ground, and connected by subterranean galleries for the service of the attendants.

The Krupp establishment uses in its crucible steel plant about 130 coke and 30 gas ovens. Each oven has a capacity of 12 crucibles. Some however can hold 18, so that casts of from 1,600 to 1,800 crucibles, even more if necessary, may be easily undertaken. The largest steel blocks cast at Essen up to the present time weigh 70,000 kilograms, required in the construction of the 120-ton guns. About 1,700 crucible charges were needed in casting them.

Along the center line of the structure the casting pits are dug, and the movable cranes are located. The process of casting is in itself of absorbing interest; it is a striking illustration of the precision and coolness of the master founder, of the discipline and skill of the workmen.

When the steel in the crucibles has reached the desired melting temperature, after being from four to five hours in the furnace, the master founder places the mould, as near as may be, equidistant from the active ovens. He then sets up the casting runners, heavy sheet iron channels lined with fire-brick. These runners lead the liquid metal in corruscating streams to the gate which surmounts the mould in which they are engulfed. The foundrymen are dressed in two long lines, facing to the centre and divided into threes and twos. One of each three, carries a tongs, the others a rod very much like a brewer's mash ladle. As soon as the master founder has completed his preparations, and, upon in-

spection ascertains that the proper melting point has been reached, he gives the signal, the oven covers slide back, and the casting begins. The melter with the tongs clasps the crucible and resting the curved tong handle upon the rod, held by the other men as a fulcrum, he lifts it out of the oven. Keeping it vertical, the three place it on the ground some distance from the furnace. Then the other two take it, and pour its contents into the runner.

The empty pots are thrown in a heap out of the way of the workmen. Group silently follows group; the crucibles shimmer through the foundry in a meteoric shower; the silence is broken only by the clatter of the sliding oven covers and the crackling of the molten streams as they glide in the runners toward the flask into whose fiery mouth they plunge in a glittering cascade.

The incessant sheen which intoxicates the eye, the intense heat coming in blasts from the underground fires, the silent traffic of the workmen, all bring to mind some witches' Sabbath of the Reign of Terror. In a word, it is a magnificent drama of intense coloring and unapproachable grandeur, worthy the brush of a Callot.

To those who feel it incumbent upon themselves to suggest that we are drawing upon our imagination, rather than our memory, that enthusiasm induces us to throw a halo about the description, we can only reply, ask others, who like ourselves, have *seen*.

We may say that it is mathematically certain that the casting, even if an 80,000 kilogram ingot be in question, *cannot* fail.

Krupp's workmen are thoroughly trained in that iron discipline, well taught in that characteristic Prussian school of steadiness, which affords undoubted assurance of success. Cast-steel chills quickly; the ingot is drawn from the pit by one of the powerful foundry cranes, and

carried to an adjoining shop, where a fire-brick wall is built about it, to prevent chilling to the very core, which would retard forging. But before the block is shaped, it is reheated in one of the furnaces convenient to the hammer, and at the right temperature, it is taken out, swung by a triple chain-sling to a crane, which by deft movement, lands it on the anvil.

XIV.—The 50-ton Hammer.

A word about the 50-ton hammer, so long the boast of the Krupp Works.

Imagine a square steel head, 3.70 metres long, 1.50 metres wide, and 1.25 metres deep, a mass of seven cubic metres, hung at a height of 12 feet in an arch five metres high, whose supports are 1.50 metres in diameter. Now a steel anvil, resting upon successive foundations of masonry, oak, a whole forest was required, and cast-iron, finally, in your mind's eye, put the glowing ingot under the hammer head. The hammer boss, a veteran artist in blue glasses, for it is impossible to watch the incandescent mass with the naked eye, is in direct charge. At his right and left are the men who grasp the chains encircling the monster, and who, at a hand wave, without a word or order, oscillate the block until the desired position is attained. The hammer slowly descends, the head hardly touches the ingot, then, after a rapid inspection, it is quickly raised, and comes down with all its might upon the metal which quivers and gives under its terrible blows. About the hammer the ground trembles as with an earthquake wave. Stop! the hammer rests, the block is turned on its side, the machine takes breath again like a Colossus raising his club to brain the enemy, and pounds again upon the bruised mass, which finally gives way under this storm of blows; the block is forged.

The 50-ton hammer was built about twenty years ago and cost the small sum of 500,000 dollars, but it must be admitted in excuse that it earns its living honestly, and pays good interest on its cost. At that time Creusot had only a 12-ton hammer; now however there are 80 and even 100-ton hammers.

"Why," it is asked, "does Krupp suffer himself to be outdone by his rivals?"

We must first note that the Essen hammer has really an effective weight of 60 tons, and the heaviest blocks forged weigh, as already mentioned, 70,000 kilograms. These blocks are bored; the forging can therefore be altogether effective, for the hammer blows need not penetrate to the heart of the block. Further the monster guns now constructed date back only a few years. Although up to the present, more powerful mechanical contrivances were not required, yet for some time past, Krupp has contemplated erecting a hammer of much greater weight, and the matter is so far advanced that within a few months Essen will again surpass its rivals in its ability to forge the very heaviest steel masses. It would hardly be proper for us to say more on this subject. After forging, the shapes are subjected to a peculiar annealing process, and are then transferred to the gun shops for finishing and assembling. We will not dwell upon the other products of the Works, steel-cast wheels, coil and elliptical springs, tires, &c., all abounding in interest, and which in themselves justify Krupp's great reputation. We examined the entire plant with sustained interest, but we cannot within the scope of this paper, undertake to impart our impressions.

XV.—The Model Collection.

Before leaving, let us glance at the collection of models, or rather the museum of the Krupp Establishment.

It contains specimens of every gun and military construction designed or improved by Krupp; it tells the eloquent story of his researches and his labors. Here are steel and iron plates which have been used as targets in the various experiments that have lengthened out the struggle between armor and gun; here are samples of ores, test pieces of gun metal, fragments of experimental guns fired to destruction, mute witnesses to the enduring patience and multifarious knowledge which characterize the continued researches of the tireless German Constructor.

Here can be seen all the stages of his fermature, before it reached its present degree of perfection. Here are guns of all systems, the breech mechanisms of Wahrendorf, Kreiner, and others, in a word, everything to interest Artillery and Ordnance officers of every country. In the centre of the museum stands, bright and attractive, a Prussian battery, as it leaves the Works. Every expert in the fabrication of war materials must admit that the Krupp output is treated, even to the smallest details, with the utmost care.

A great General has said "that the Prussian army is the most perfect military machine in the world," surely then its present war material deserves a large share of this meed of praise.

We must not overlook the collection of the different projectiles made at the Works, from the shell for the 7.8 cent. gun, to the 1,050 kilogram hammered and hardened steel armor-piercing shell for the 120-ton gun, culminating in one still more phenomenal, 1.80 metres long, (4 calibres), weighing 1,500 kilograms, to be fired from the projected 45 cent. gun of from 140 to 150 tons weight.

XVI.—Krupp's Proving Grounds.

Krupp has facilities in connection with the Works for proving finished guns. The piece is placed in a vault

whose walls are thick enough to retain the fragments in case it should burst during endurance trials. The gun is brought to the shaft by rail, and lowered upon the carriage by a crane. At the word "ready", everybody leaves, and the piece is fired by electricity. The projectiles lodge in a butt, 100 metres in front. This test, we repeat, is for the purpose of noting the general behavior of the piece, but also gives the initial velocity and the gas pressure.

Complete ballistic experiments, the determination of ranges, accuracy and similar data, are conducted at the Meppen Proving Ground, owned by Krupp, where, thanks to a range of 16,800 metres and the latest apparatus, they can be pursued on the most extended scale.

XVII.—An Epitome of the Krupp Plant.—Krupp.

We conclude our task with some data which will give a better idea than any words of ours of the magnitude of the Krupp plant, and its steady progress since 1810, the date of inception.

In 1883 the plant comprised:

1.—The Essen Steel Works,
2.—The Essen and Bochum Coal fields,
3.—547 Iron Mines in Germany,
4.—Several ore beds near Bilboa,
5.—Four Smelting Works near Duisburg, Neuwied and Sayn,
6.—The Meppen Proving Ground,
7.—Four Steamships,
8.—Various stone quarries, clay banks, and sand pits.

There are in operation:

11 Blast furnaces,
1,542 Furnaces of various kinds,
439 Boilers,

82 Steam hammers from 100 to 50,000 kilograms,

21 Roll trains,

451 Steam engines, of 18,500 horse power total capacity, of which many, we are glad to say, were made by Vanden Kerchove, the well-known Ghent builder, and finally,

1,622 machine tools.

The total output of the Essen Steel Works amounted in 1881 to 260,000 tons, including Crucible, Open-hearth, Bessemer steel, and Homogeneous Wrought iron.

It is generally supposed that Krupp manufactures only guns, of which he has made to date, 21,000; carriages, ammunition wagons, projectiles and fuzes, in a word, ordnance material only.

He also supplies, as we have seen, rails, switches, axles, tires, locomotive and car wheels, everything required for road beds or rolling stock; he rolls boiler and ship plates, constructs bridges of all kinds, forges crank-shafts, anchors, and structural parts for the merchant and naval service.

He serves the wants of commerce and trade as satisfactorily as he meets the demand of warfare. We will add some figures, gleaned at hap-hazard;

The Works consume:

Coal and *Coke*; 3,100 tons per work-day, about 1,400 tons of which are chargeable to the blast furnaces and steamers.

Water: From 5,000,000 to 7,000,000 gallons per work-day.

Gas for lighting: From 475,000 to 1,500,000 feet per work-day.

The blast furnaces are charged daily with 1,400 tons of ore from the Krupp mines. The shafts and drifts deliver daily an average of 3,000 tons of coal.

For internal traffic there are 27 miles of railroad standard gauge, with 14 locomotives and 539 cars, and

15½ miles of narrow gauge road, with 14 locomotives and 344 gondolas. There are besides 71 horses with 191 carts, 40 miles of telegraph lines with 35 stations, and since 1884, 100 telephones.

The plant has exclusively for its own needs, a chemical laboratory, a photograph gallery, a printing office, and a book bindery. There is a fire brigade of 70 men and 32 fire alarms. The Commissary Department, whose transactions in 1882 reached nearly a million dollars, includes; a hotel, nine beer gardens, a mineral-water factory, a steam grinding mill, a bakery, an abattoir, one clothing and two shoemaking establishments, forty-six grocery, haberdashery, dry goods, hardware and other shops.

At the last general census taken in September, 1881, the total of employees footed up 19,605, of whom 11,211 belonged to the Steel Works, and 8,394 to the Smelting Works, mines, &c.

The other members of the families numbered 45,776, of whom 13,083 were school attendants, so that the entire population dependent upon the plant amounted to 65,381 souls. 18,698 of these occupied dwellings belonging to the establishment. We will not speak of the various institutions for the public comfort, the dormitories for unmarried men, the baths, hospitals, manual training schools.

According to the old saying that "the left ear rings when good is spoken of us," Krupp must be unable to hear his own words, for no one else does the good he does.

A word concerning Krupp, the very soul of what we attempt to describe.

The present owner is an octogenarian, whose rugged health and ceaseless activity defy age and sickness.*

* Since these lines were written, the world has been called upon to mourn the death of Alfred Krupp, crowned with years and honours, July 14th, 1887. See "Alfred Krupp; a sketch of his Life and Work," New York, 1888.

He is still the prime mover in all the great enterprises, undertaken by the Works. As Commodore Vanderbilt was called "The Railroad King," so has he been named "The Cannon King."

This regal title—hardly intrinsically applicable to the great American financier, who restricted himself to the purchase of blocks of stock in sound and paying roads, and never built a mile of line in his life—is a just tribute to Krupp, for he *himself*, made not only the guns but also the necessary metal.

E. MONTHAYE.

APPENDIX.

REGARDING

KRUPP AND DE BANGE.

AN ANALYSIS OF SOME CRITICISMS MADE UPON CAPTAIN MONTHAYE'S BOOK

BY

PERTINAX,

Graduate of the Belgium Artillery and Engineer School of Application.

"I am not animated by that narrow patriotism which demands that the Administration should purchase poor material in Belgium, when good can be procured elsewhere."

Extract from the speech of M. Neujean, Deputy from Liége, at the Chamber of Representatives, May 20th, 1887. ***Parliamentary Annals,*** **p. 1158.**

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CHAPTER I.

A Red-covered Pamphlet.

Ordnance experts and steel makers may be divided into two classes, those who believe that crucible steel is the only material for guns, and those who are willing to accept *any* steel, without questioning its origin or fabrication, provided it comes up to specification.

In Belgium we find active partisans of both schools, especially in the Ordnance Corps, and, though closely contested, the question to-day is far from settled. The Belgian steel makers, however, are a unit in support of the second class, for the very simple reason that we have no plant for making crucible steel under the required conditions. The occasion always furnishes the man. Thus the *Journal de Liége* has brought to light among its editors, an ardent advocate of confining the manufacture of guns to national industry, an industry, by-the-way, which has its seat in Liége and its environs. In many editorials, somewhat local in spirit but otherwise well-written, this aptly provided writer undertakes to demolish the arguments of the believers in crucible steel. By natural sympathy, (for all are in the same boat), for the system of De Bange, who is also *necessarily* opposed to crucible steel, the champion of the Liége steel industry takes up with boyish enthusiasm the cudgels in defense of the French constructor and in

opposition to the Essen steel maker. The most recent articles from the *Journal de Liége* have been collected and published under red covers as an "Open Letter to Lieut. E. Monthaye." It is not our intention to iterate here in their entirety the arguments advanced by the two parties. Those of our readers who are desirous of thoroughly sifting this question should read the excellent work on this subject, just published, entitled "Krupp and De Bange" by Lieutenant E. Monthaye, recently promoted to a captaincy in the General Staff. We only propose to answer some objections which have appeared in the papers and elsewhere, since the issue of this book, aimed at Krupp steel and Krupp guns; a task we gladly undertake, because we, with hosts of others, believe that the Krupp method, embracing both material and construction, is the only scientifically sound one.

***

Some advocates of Krupp steel, relying upon the logical and carefully considered views of Frémy, Valérius, Seebohm, and other eminent scientific and practical experts, have ventured to regard as established, the superiority of crucible steel as a gun-metal over Bessemer, open-hearth, and other varieties.

Forthwith, the *Journal de Liége* puts on its war paint, and calling to the rescue that member of its editorial staff who also functions as a corporal of militia, in "one time and one motion," makes away with all these authorities. Gladly if it dared, would it regard them as obstinate opponents of progress, old fogies, whose writings—antiquated tomes—are only worth pres-

ervation, on the shelves of some alchemist's cabinet. But then, why will these conscript fathers of science, not to be confounded with "Modern Science," the true fountain of life, indulge in views not in harmony with the interests of Belgian industry?

The *Journal de Liége* writer, who is a patriot, a warlike one at that, for he is a corporal of militia, poses as the high priest of mighty science, of "modern science," of "Belgian science above all." This science is only for the initiate; no one may criticise its dogmas without the risk of being overwhelmed with the whole string of anathemas launched with such gusto by Doctor Pancrace upon Sgnarelle in Molière's "Marriage forcé." But let us hasten to defend science, "old style," against science, "new style patented" of this high and mighty doctor of Tubal Cain's art, Sir Corporal of the *Journal de Liége.*

***

According to Frémy, the ideal gun-metal should be made of charcoal iron and cement steel, melted in crucibles; but, adds the distinguished chemist, the production of these components is too limited and their cost too high to admit of their general use in gun construction.

The representatives of this "modern science," who throne it so lordly in the *Journal de Liége*, do not accept this conclusion, which the French scientist bases upon economical considerations, and, we hasten to say, with some show of reason. "Sweden alone" they answer, "not counting Russia or the United States, produces annually about 250,000 tons of charcoal iron, of exceptional quality and low price, most of which finds

its way to England and America as raw material for cement steel." But this is not the question. It is clear that if Krupp deemed it advantageous to use charcoal iron alone in making crucible steel, he could easily produce it in one of his Siegen blast furnaces; but he regards the coke iron he uses as possessing the requisite purity. Indeed it does not follow as a matter of course that charcoal iron is *necessarily* purer than coke, for a pig made with the best quality of coke from very pure ores, may be as good as any charcoal iron. This is Krupp's case, for he works with coke and ores of remarkable purity; as a result he gets for his steel, iron of the very highest standard.

Hence the *Journal's* taunt that Krupp does not follow the very first precept of Frémy falls to the ground.

There is another factor which assures *chemical* purity for Krupp's crucible steel; all the ingredients which make up the crucible charge, iron as well as steel, come from puddling pig metal.

The refining character of this process is well known. Should for instance, there still remain in the pig traces of phosphorus, they are eliminated in the puddling furnace, so that the iron and steel, produced by this method, offer an additional guarantee, not applicable to open-hearth steel.

Besides, the purity of cement steel depends in the same way upon that of the material of which it is made; it cannot be purer than the puddled iron, its base. This however, is made by the *same* process Krupp uses for his puddled iron and steel. For these reasons, the two constituents of Krupp's crucible steel, *iron* and *puddled*

steel, possess *chemical qualities* fully equalling those of the choicest components used in any establishment where steel is made, not in small and costly specimens, but for every demand requiring a metal of high grade.

***

The "professors" of the *Journal de Liége* maintain that the Martin-Siemens furnace, which Frémy expects to be so much improved in the future, has fulfilled all its promises, they claim that its product is as homogeneous as crucible cast-steel. A few "common-sense" metallurgical considerations will, we hope, prove the contrary. Krupp takes his iron and puddled steel in given proportions for the charge of the hermetically sealed crucible, and remelts them without exposure to either gas or air. In this way he secures for the result, whose *chemical* purity is already assured, the desired constitution and absolute *physical* homogeneity. The minute impurities still held by the iron and steel come to the surface of the charge, which is kept in undisturbed fusion for some hours, and in pouring remain in the crucible.

In the Martin-Siemens process, on the contrary, the oxydizing iron and steel scrap are fused in a bath of cast-iron in the furnace under the direct action of the flame, which cannot always be maintained free from an excess of air; the oxygen of the scrap combines with the carbon of the pig, the gaseous product escapes, and there remains a liquid mass of metal lower in carbon. This is open-hearth steel, the present main gun-metal of England and France. It does not require profound metallurgical knowledge to comprehend that such a metal does not

offer the same guarantee of *uniformity* and *homogeneity* as crucible steel. Of course it is possible to cast ingots of open-hearth steel, to roll them, and to remelt the bars in a regenerative furnace. Undoubtedly a better metal would thus be obtained than by the open-hearth process *pure and simple*, but even in this case, the steel bath is exposed to the direct action of the flame and gases, and scum is formed upon the surface which at once reacts upon the liquid mass. We may therefore be sure that even this metal, made by the improved method, does not merit the same confidence as regards homogeneity as does crucible steel.

Whitworth also uses the open-hearth process for gun-metal. His method of compressing the liquid steel mechanically, so highly praised, has long ago been acknowledged as insufficient and useless, for the reason that it is essential to produce ingots without blow holes *in the very casting*, and the compression has no greater effect than can be attained by hammering, necessary under all circumstances.

We submit these remarks in good faith to the "new science" gentlemen of the *Journal de Liége*. Perhaps they may admit that it is not altogether an impossibility that Krupp metal is superior to its rivals, especially for gun construction.

The reasons we have adduced to establish our point are precisely the same as those given by the famous metallurgists, whose conclusions the *Journal de Liége* rejects with disdain because upset by "modern progress." The metallurgical methods followed and described by these experts have undergone no change in

principle and even if the danger of blow-holes, in open-hearth ingots has up to a given point been overcome, the modification of the process has given rise to other drawbacks, and has left untouched all the other causes which tend to impart uncertainty of constitution, an attribute characterizing this metal,

The Martin-Siemens process has to-day the same value in producing gun-metal as it had in Frémy's time ; it is inferior, and greatly so, as regards *uniformity* and *homogeneity* to the crucible method adopted for this purpose in Krupp's Works.

***

We agree fully with Lieutenant Monthaye in deeming as a striking confirmation of his conclusions the recent gun experience of England and France, and Colonel De la Rocque's criticisms upon French gun steel, not only that supplied in 1872, as it would erroneously appear to the corporal-professor of the *Journal de Liége*, but in the entire period from 1861 to 1887. Colonel De la Rocque can speak authoritatively on this matter, for his official connection with Government Foundries has afforded him abundant opportunity for examining and testing the steel blocks furnished by French Works. The facts cited by him show that even at the present time French gun steel still lacks homogeneity. We repeat, upon this matter, Colonel De la Rocque is an expert, for he speaks of what he has *seen* and *tried*, but in his criticisms of Krupp guns this is not the case ; he had no personal knowledge of Krupp methods, and, not being a fine German scholar, he has not translated cor-

rectly—Lieut. Monthaye gives some telling instances—the German treatises on the subject.

***

An apparently strong argument can be advanced. The question may be asked, as was done by the *Journal de Liége*, "Why does not France, if Frémy's investigations really proved the superiority of crucible steel, use this make for gun-metal?"

Of course, the cost of plant, in so important a matter, need not be taken into account, especially in connection with so great an industrial nation as the French. This is not the reason; two inducements led France to make what we must call, a mistake, one, the potent influence of the leaders of "modern science" who positively asserted that the open-hearth furnace would yield a metal, if not at once, at least very soon, fully equal to crucible steel.

This assertion appeared to be confirmed for the moment by various mechanical tests of open-hearth steel which showed that it possessed apparently identical physical qualities.

Nowadays, this sort of test, based on a few figures, formerly deemed of great importance by the authorities, has not so much weight given to it, and practical *experience* upsets preconceived ideas. It has been proved, and is now generally accepted, that satisfactory results obtained with good test specimens cut here and there from the ingots, do not determine the quality of the entire block. The testimony of Colonel De la Rocque upon

this point is irrefragable, its vital bearing in the discussion cannot be gainsaid.

In drawing broad conclusions from the data of restricted tests there is danger, as is readily seen, of great miscalculation.

In this same train of thought, we believe that too much weight should not be attached to the recent Woolwich experiments of Professor Abel and Colonel Maitland. This investigation covered the resistance to erosion offered by steel of various makes and different degrees of hammering. The future will demonstrate whether or no these results, quoted with such evident satisfaction, are not more apparent than real. Let us wait until then.

The second inducement that led France to reject crucible steel for gun construction, lay in the difficulty of producing it in great blocks, weighing 70 tons or more. This requires something beside the preliminary providing of some thousands of crucibles, the only condition, so it seems to the correspondent of the *Journal de Liége*, required to be fulfilled.

But our "corporal," who is as bright as though he were not a corporal, knows better, only he is too regardful of others' feelings to say so. On the other hand, since, from *inability* to cast great ingots, open-hearth steel *had* to be used for heavy guns, there was the more reason for using it for medium and light pieces.

It is true, as observed by the correspondent of the *Journal de Liége*, that there are small Works in France where crucible steel is made, but—he should have added—for some special purpose where cost, as compared

with exceptional excellence, is not taken into account. We have in mind especially tool steel.

The statement however, was unwise, for the *Journal de Liége* thereby itself admits that even in France, when steel of unsual high grade is required, recourse is had to crucible. We have the right to conclude from this admission that even the *Journal* acknowledges—in private be it understood—that for *special application* crucible is superior to open-hearth steel.

***

The *Journal de Liége* interprets from its own standpoint, some recent comparative tests with Krupp and French battering shells at Spezia and Saint Petersburg. The *real* truth, for it appears there are several kinds, can be gleaned from all the trustworthy reviews. Here it is.

At Spezia, the Krupp shells proved far superior to those of French make. At St. Petersburg, there were in some of the tests slight differences in favor of the French shells.

But it is unquestionable that, in the quality and fabrication of steel battering shells, Krupp is always in the lead, notwithstanding the efforts of his French rivals. Another point to note, one which has not escaped the attention of the opponents of crucible steel, the French projectiles in these trials were made, according to the *Journal de Liége* of crucible, not of open-hearth, steel. Will the French steel makers apologize?

In concluding what relates to Krupp metal, we invite the correspondent of the *Journal de Liége* to rely more

upon his own fairness and good sense, and not to trust so blindly to opinions advanced with such apparent striking pertinence by a so-called "modern science."

If he did this, he would, with the gentlemanliness we willingly accord him, acknowledge that a man might be an advocate of Krupp metal without making it a fetich.

***

The friends of Krupp have been criticized for not making use, in comparing the Krupp and De Bange systems, of the tables of the Caïl Company, as well as those of the Essen Works. The criticism is not just, for the Cail tables give only approximate theoretical results with guns not yet constructed, except for pieces identical with the corresponding French standard models. It cannot be disputed that the range tables of these latter must be valid for similar guns supplied by the Cail Company. Krupp's tables possess quite a different importance and reliability, due to the fact that every one of the guns compared with the De Bange, has been furnished to some nation or other. Krupp issues *with each piece, range tables*, tables usually drawn up under the eyes of the inspecting officers, who, besides, at Meppen have the entire control from beginning to end.

Hence it is a simple matter of personal interest for Krupp to make his tables comport with the actual results.

We believe that up to the present time no customer's confidence in the German Establishment has been shaken.

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It is not our intention to enter upon a theoretical discussion of the respective merits of the Krupp and De Bange fermatures. Those who regard with doubt the utterances of the adherents of the rival systems, and rely upon experience alone,—after all, as said recently by the *Army and Navy Gazette*, the crucial touchstone in so important a matter,—will be well pleased if they give careful consideration to the following: Since the introduction of the De Bange fermature side by side with the Krupp, various States have adopted new systems of field artillery. Which one has adopted the De Bange gun? One only, Servia, and under well understood politico-financial pressure. It is true that Norway has also adopted the De Bange breech mechanism—but applied to Krupp guns.

We shall revert later to this matter. On the other hand, among the greater Powers, Italy has adhered to the Krupp mechanism for its new field pieces of swaged bronze now making. Yet, when this decision was reached, the De Bange system was well known in Italy. Turkey, in introducing the new field artillery material made at Essen, has also adhered to the Krupp fermature.

Bulgaria has done the same. The Dutch Commission sent to witness the Bucharest trials, and which watched *the working of the Krupp gun in connection with the De Bange*, confirms in its report the superiority of the German over the French system.*

**The Bucharest Trials.*—Extract from the Report of the Netherland Commission. Brussels, Vanderlinden, 1886, p. 42 *et seq.*

Belgium subjected the Krupp fermature to tests, and then adopted it for its new field equipment.

The important bearing of such facts can be denied only by prejudiced individuals. The De Bange system has been adopted in France. How about this? We have no desire to stir up acrimonious discussion in regard thereto; we refer the reader to the criticisms of the French press itself, criticisms though discreet and to be read "between the lines." For our part, we repeat, we have no desire whatever to engage in epistolary warfare with the French partisans of Colonel De Bange; they have their hands full in the task of meeting the recriminations of their own compatriots.

As to the Servian argument, here is a page of contemporaneous history, very singular on account of the circumstances it discloses. We offer it to those who are still in doubt.

In its issue of April 3 (new style), 1887, *Odjek*, a Belgrade paper, published the following: "We have now new guns, but the question is, what are they worth? We must announce with dismay, that although we have them, we are no better off than if we had no artillery at all." .... "Is it a secret that all the Colonels one after the other, have reported upon the defects of their pieces? A summing up of all, shows not less than ninety." We must mention that in its issue of April 13, the same paper publishes a denial from an official source, which renders nugatory its statements of April 3. The correction closes thus:

"The Minister of War makes light of our desponding, and, in the face of our fears, asserts the efficiency

of our new equipment in saying that when called upon, it will brilliantly meet all demands."

Stung by this reprimand, *Odjek*, in its issue of May 1, comes to the point, and publishes a list of forty-two defects reported by the commandants of regiments to the War Department, and the steps taken to cure them. As we are here discussing only the question of fermatures, we will content ourselves with a taste, and quote only one of the defects of the De Bange fermature, and the decision thereon of the Servian War Department.

"*Second defect.*—In rapid firing it is difficult to lock the screw on account of fouling. It has happened that the breech-plug could not be opened after the first round."

"*Decision.*—That this should occur no more, all fermatures should be well oiled after each round, or after every second round. Those fermatures which cannot be opened after the first round should be examined by the armorer with a view of repairing them. Besides, it is necessary in all fermatures to smooth the edges of the screw threads with a file." Here you have it! The first defect, which according to Lieutenant Monthaye, attaches to the De Bange fermature, the possibility of upsetting the metal of screw and nut, is confirmed by the most recent practice. As to the second, the possibility of unbreeching by the wrenching of the tube, due to the sudden, uncushioned effect of the gas-pressure upon the bottom of the threads, a proof exists in the frequent tearing off of the breech of French field-guns.

The ease of working and the exemption from danger of fouling claimed for the De Bange fermature is rather

placed in doubt by the recent experience, instructive in every respect, of the Servian Artillery.

***

We learn from *Engineering*, that recently in Norway the De Bange gun came out ahead of the Krupp in a comparative test, on account of its accuracy and a host of other good qualities.

This is strict truth, in so far as the Christiana Board has reported in favor of the adoption of a gun with De Bange fermature, but it was forgetful not to state that the gun is the 8.4 cent. Krupp, the same model that competed at Belgrade, *except as to fermature.* We are convinced that this material, furnished by Krupp, will be free from the weaknesses, so glaringly manifest in the Servian pieces supplied by French makers. The new Norwegian equipment will have then in all essential points but one, the superior attributes conceded to Krupp guns; but we still insist in doubting the real, practical value of the French fermature.

We fear that in this respect the Norwegian Artillery will undergo a rueful experience.

The De Bange gas-check for heavy guns has been adopted in England, that this was a success for the constructor, no one will deny. But, after the accidents to the guns of the "*Ajax*,"—we refer to the *Times* concerning them—the enchantment ceased, and most significant fact, the new 110-ton Armstrong guns, constructed for the English Government, guns with breech-plugs having movable heads etc., are to be furnished neither with the Armstrong cap, nor with the De Bange plastic gas-check,

but with a *modification* of this latter system, proposed by Mr. Vavasseur.

It is evident that if the De Bange gas-check had answered all demands, it would not have been necessary to embark upon a new, untried construction.

***

Engineering, in its issues of February 4, and 18, makes a comparison between the ballistic effects of the Krupp 120-ton and the Armstrong 110-ton gun, a comparison which it turns to the advantage of the latter. Of course this is proper patriotism, decided Jingoism, but is it the truth?

We have lately received *Krupp Report* No. LXIII, published in July, 1886, in which occurs this passage:

"The four 40 cent. guns, 35 calibres long, have in every respect come up to specification. Gun No. 19, 464, which has fired 66 rounds, shows signs of scoring, as might have been expected in so great a piece with 330 kilogram charges; but this scoring is so exceedingly slight that no lengthening of the chamber can, up to the present time, be detected, as shown by accompanying measurements. This gun will soon be tried with still heavier charges, and with new kinds of powder. For this purpose, the gun has been already remounted at Meppen, and the trials will begin next August. The other three pieces will soon be sent to their destination." The fourth 40 cent. gun, contrary to popular belief has not been sent to Italy. Experimental firing was continued with it at Meppen in August and September, 1886,

Krupp Report No. LXIV, published in September, 1886, gives the later results.

We have drawn thence the subjoined data for comparison with the maximum effect thus far produced with the Armstrong gun.

Gun.		Date of Firing	Weight of			Initial Velocity.	Muzzle Energy.		Pressures by Crusher Gauge.	Thickness of Hammered Plate penetrated at Muzzle.
			Gun.	Charge.	Projectile.		Total.	Per kilog. of Wt. of Gun.		
	Calibre.		Tons.	Kil.	Kil.	Met.	Met. tons.	Kil. M.	Atmos	Cent.
Krupp.... .	40 cent. 35 cal. long.	Sept. 28, 1886.	121	384	1,050	579	17,940	149	2,860	119
Armstrong.	41 27 cent.	Mar. 3, 1887	111.76	386	820	655	17,949	161	3,025	114

A projectile of the same weight, (820 kilograms) as the Armstrong, would receive with a charge of 384 kilograms in the Krupp gun, an initial velocity of about 650 metres. The pressure of 2,860 atmospheres is perfectly admissible in the Krupp gun, while according to *Engineering* of February 17, 1887, the pressure in the Armstrong with action charges should not exceed 2,600 atmospheres. It follows then that for the *maximum* effect, as given in the above table, *the pressure is considerably higher than prescribed by the Constructor.*

Lately it has been stated that the gun is warranted up to 3,800 atmospheres, (*Engineering*, May 13, 1887) but we prefer to stick to the figures given by the maker himself.

This article, in *Engineering* of May 17, is a comparison between the two guns, made by Mr. Longridge.

We earnestly recommend its perusal to the "Corporal" of the *Journal de Liége*, without however being conceited enough to hope that all the author's conclusions will be to his taste. Yet, this in the way of caution, we avow having little faith in the proposed steel wire-wound guns of the English writer. It must be acknowledged that the 40 cent. guns supplied by Krupp to the Italian Government have nothing to dread, even under ballistic performance, in a comparison with the latest output of the Elswick Works. Besides it must be borne in mind that this new Armstrong gun is, at best, but an *experimental* piece, whose construction involves altogether untried innovations, and as to whose accuracy, we have as yet no data.

CHAPTER II.

A Yellow-covered Pamphlet.

Havermans of Brussels has recently issued a little yellow-covered pamphlet, entitled: "The Gun Question," and signed by Lieutenant J. Malengreau. This young officer is a voluminous author; it will be said of him–we fear with truth–that the number of his works, which all resemble each other, detracts somewhat from their quality. Like its predecessors, the new pamphlet is not destined to revolutionize the art; being of the still-born class, it does not even possess a death-bed glamour. In other words, we shall not criticise all the "godsends," discoverable in its forty-three pages, it would take too long, and be of very little use. It is worth while however, from abstract considerations, to call the attention of the readers of this booklet to two points:

1.—The author's method as regards those who differ from him.

2.—The degree of competence possessed by him.

We have neither the right, nor the duty to undertake, as against Mr. Malengreau, the defence of the author of "Krupp and De Bange," but if Mr. Monthaye disdains to reply to the controversial methods we are

about to stigmatize, we shall obey the instinct of professional fellowship by nailing them to the pillory.

How has Mr. Malengreau proceeded in his attempt to convict his opponent of recantation of opinions? He has picked from his writings a number of apparently pertinent passages, put them cleverly together, (is cleverly the right word?) and thus formed a whole, which at the first blush, appears consistent.

He has thus most disloyally misrepresented his comrade's views.

It would be a deserved punishment for Mr. Malengreau to print his mutilated quotations in juxtaposition with the original text, and restored amid sentences which give them their true import; but this punitive task is little to our taste. We content ourselves with denouncing the method without more severe comment, leaving it to every one to form his own opinion.

Is Mr. Malengreau more competent than he is loyal? In "Krupp and De Bange," on page 48, under the heading, "Mountain Guns," occurs this sentence:

"The *excessive* weight of the French projectile reduces the number carried by each pack animal, a very important consideration; and, as a result of the low initial velocity, the shock of the recoil is harder on the carriage, which is therefore more strongly constructed than the German, and is of course, much heavier."

Mr. Malengreau thinks it necessary to prove his ignorance, by annotating the passage in this ridiculous fashion: "Any comment would dim this pearl!"

We have no especial desire to instruct, but we can-

not here resist the temptation of placing before the author of "The Gun Question," this simple demonstration.

Let

p_1 =weight of the projectile.
v_1 =its initial velocity.
P =weight of gun and carriage.
V_1=mean velocity of recoil.

The mean velocity of recoil is approximately determined by the equation:

$$PV_1 = p_1 v_1 \ (1)$$

assuming, with the same charge, a projectile weighing

$$p_2 > p_1,$$

we can find its velocity from the equation:

$$\frac{p_1 v_1^2}{2g} = \frac{p_2 v_2^2}{2g} \ (2)$$

in which g is the acceleration of gravity. With the projectile whose weight is p_2, the mean velocity of recoil, V_2, is given by the equation:

$$PV_2 = p_2 v_2 \ (3)$$

substituting the value of p_2 from (2), we have

$$V_2 = \frac{p_1 v_1}{P} \times \frac{v_1}{v_2} \ (4)$$

But from (1)

$$V_1 = \frac{p_1 v_1}{P}$$

From which follows that in firing successively heavier projectiles from one and the same piece with constant charge, the mean velocity of recoil of the system *increases* inversely as the initial velocity. As the shock upon the carriage *increases* with the theoretical velocity of recoil, the proposition is proved, and Mr. Monthaye

is justified in making the statement, disdainfully called, by his presuming opponent, "a pearl." We wager that "this gentleman" (to follow his footsteps) now wishes he had not disturbed this jewel. We trust that Mr. Malengreau will in future be more cautious, and that before attempting to belittle the knowledge of his colleagues, he will set himself to work to fill up the constantly evident voids—and the case cited is to the point —in his own technical education.

Mr. Malengreau, a graduate of the Academy, which entails a certain presumption of literary capacity, ought to have better command of the language of Voltaire and Buffon.

He concludes the yellow booklet in question with this remarkable sentence :

"Modern Artillery has not uttered its last word; we are later than others, we can thus profit by their experience, and, appropriate the good points of each of their system" (*de chacun de leur systéme*).

Modern Artillery has not utlered its last word. True, but common-place and hackneyed. *We are later than others.* "Others" is rather vague, almost dreamily so. *We can thus profit by their experience.* This is logical and indisputable. *And appropriate the good points of each of their system. Of each of their system?*—that requires reflection. *Each of their system* is surely unpublished. All praise to the unappreciated genius who brought this pearl-bearing oyster to the surface ; it is large, and, doubling its value, of exquisite flavor.

We conclude with these words to Mr. Malengreau: If, dear comrade, you believe that your writings help to "push" manufactures along the shores of progress, and to "enrich" literature with new masterpieces, attach no value to these illusions! Abandon the part you cannot play, give up the fight for which you are not fitted, or else, some day, some very, very distant day, —for we do not pray for the death of the sinner—there will be found somewhere this epitaph, sadly yet strikingly suggestive:

Much did he write
All of a comic kind.
Many delight
His pen no more to find.

CHAPTER III.

The Patriotism involved in the Gun Question.

Those who favor Krupp guns expose themselves, as has happened and will unfortunately continue to happen, to the charge of want of patriotism, while by extolling the merits of the Cockerill or even of the De Bange ordnance,—for according to the views of some we should have a high regard for the French guns—one becomes, without opposition, a great man.

It is indeed an easy task to flourish before the public gaze, the image, so flattering to the *national* pride, of a model gun foundry, supported by *national* arts and manufactures, and supplying not only *national* wants, but as formerly, the wants of the whole world, even China not excepted. Just look at this enchanting picture. China, thanks to Belgian guns, a factor in the world's "balance of power!" Alas! this is but buncombe and illusion; all this might have been possible, fifty years ago, but instead of at that time changing by radical, fearless measures our gun foundry and adapting it to the new demands of steel making, we have allowed it to fall away, to die a slow death. Its patrons have abandoned it for those, who, like Krupp, have frankly admitted the possibility of progress, and who have had time to strengthen their position and render it unassail-

able. Even Colonel De Bange has come too late upon the scene, and while he has been so fortunate as to see his system adopted by his native land, he must plainly see also, that it is difficult, if not impossible, for him to contend against the competition of Krupp, of Armstrong, and of Whitworth, in supplying other countries.

Where Colonel De Bange has not succeeded, where occasionally and only with great difficulty, Armstrong and Whitworth have gained partial laurels, we cannot entertain any reasonable hope of triumphing.

Now, if we cannot expect to supply foreign ordnance needs, it would indeed be a useless waste of money to attempt to start a new industry ; it would, once or twice, supply our own needs, *exceedingly limited ones*, and it would then perish for want of customers.

If the State undertakes to supply the capital for a national Gun Foundry, if the State keeps up such an establisment, run by private industry, the State will soon come out behindhand. And take it all in all, why such sacrifice ? Simply to foster steel making, one industry among many, an unjust procedure and against the interests of the mass of taxpayers, entrusted to the prudent and economical guardianship of the State.

We propose to amplify somewhat upon this matter.

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It is evident, no one can deny, that it is for the interest of the army and therefore of the country, to possess an armament of the highest ballistic efficiency, an armament of the greatest endurance, a most important consideration, from the standpoint of wise

economy, an armament whose construction has had the sanction of long experience. Two points are to be considered, the metal and the system.

We will not again go into the theory of the advocates of crucible and open-hearth steel, we will not undertake to say who bears off the palm, Krupp or De Bange; we merely assert that the vast majority of Ordnance experts, the only competent judges of metal and method of construction, have declared in favor of the Krupp metal and the Krupp system. This is an incontrovertible fact, as well deny the existence of the sun.

Belgium has no plant where crucible steel is made especially for guns; she has no system of construction of her own. As a result, if we are desirous of having good guns, we are compelled either to go abroad, or to start a new industry in the manufacture of Krupp or De Bange guns of all kinds. Frankly speaking, can we hope to work under better technical conditions than the German and French constructors, the very inventors themselves?

It is self-evident that if, notwithstanding all this, the home manufacture of war material is insisted upon, we must first submit to the execution of a very lengthy and very costly series of experiments. Of course the reply may be made that this is not necessary, as we have the opportunity of adopting models of established reputation; in very fact, we profit thus by the experience of others.

This argument is specious, but it is a truth, old as the world, that practice alone makes perfect; *fit fabri-*

cando faber, said the ancients. Therefore, like others, we must begin at the beginning.

Who will guarantee that after essays without number, we shall not some day find ourselves stocked with guns fit only to be at once replaced by others? Krupp, Armstrong, in fact all gun makers, succeeded in establishing a satisfactory system only after trying many models, *one after the other*. Without claiming that an army should change its armament with every improvement, impossible as well as absurd, yet change must be made periodically; and the authorities will have a better opportunity of choosing the most perfect system, will have more assured guarantees of being well and promptly supplied, by treating with *specialists*, than if they made it a rule, themselves to undertake the manufacture of their guns. Finally, admitting for the moment that without any previous experience, private industry is invited to manufacture the war material required upon given and well-known systems, would it not be the height of folly to assume, that even with equal excellence of workmanship, our steel plants could at once produce an output as finished and as perfect, as that turned out under the eyes of already expert superintendents, by mechanics trained in this specialty for more than fifty years? "Jack of all trades, master of none," is an old saw; if one attempt to turn out the *best* locomotives, steam-engines, ships and guns, one runs great risk of generally producing only mediocre results.

We are then justified in asserting that, all gun manufacture should be preceded by extended experiment

and by long apprenticeship; the time required might be a menace to the State left unarmed during the interval, and the expense, at any rate, would be exceedingly burdensome.

It has lately been stated that of the eighteen millions appropriated since 1868 for the purchase of war materials, only *two* millions went out of the country. We do not hesitate to affirm that such a sum *at least* would be expended in trials and experiments of all kinds, if under the pretext of patriotism we abandoned the wise, economical course heretofore pursued.

On the other hand, in procuring our guns abroad, we gain the benefit of all the experiments, indispensable, of wide range and great cost, undertaken previous to the adoption of a particular type, without cost to ourselves. Surely, this is invaluable, yet as the cost is spread over the great number of guns, (21,000 for Krupp,) supplied by the maker, the tax is hardly felt. Further, we have the good fortune to obtain an armament, such at least is the case with Krupp guns, which has been thoroughly tried in wars of long duration, a crucial test which we as a neutral State, would hardly be permitted to apply. In other words, we purchase guns which have kept their promises *in the field*, yet without having had to pass ourselves, through the exacting and sanguinary experiences of this school. These advantages must appeal to all.

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There is constant progress, ordnance of excellent reputation to-day, may be distanced by the creation of

to-morrow. It is an unavoidable necessity for a country desirous of maintaining its independence to keep up in armament to the utmost extent of its means, with its possible adversaries. Heavy indeed would be the responsibility of an Administration which should fail in this essential duty of providing for the national defense.

Of course, to attain this end, painful sacrifices must be made, but we must learn to bear them; the history of the magazine rifle, successively adopted by all European armies, furnishes a striking example.

Admitting the force of the demands of progress, how does it affect those countries who undertake to make their own war material in Government establishments?

They are compelled to reorganize, with each change of armament, the major portion of their plant, or at least to undertake most expensive reformations, while the State which purchases directly from the best gun maker, economizes both money and time, and puts itself at once, so far as regards ordnance, on a level with the most favored nation. Those whose battle cry is, "the home manufacture of the country's guns", seek to impose their policy upon the authorities under pretext of keeping their steel Works going, which, to believe them, require Government contracts.

To begin with, this demand for indirect protection cannot be granted with any show of impartial, fairly dispensed justice; for all other manufacturing interests, *which have precisely the same claims as the steel interest*, would have a right to make the same demand, and would insist, the occasion offering, upon the same treatment.

The State posing as the guardian of all national productive interests makes a most alluring picture, but, as has been often shown, of a fool's Paradise, especially when it concerns a country which, like ours, is glutted with production, and which must therefore insist upon Free Trade. Do they argue abroad as do our manufacturers? By no means. Germany buys our machines and other products, apparently, we surmise, because she finds them better made and more economically finished than at home. In acting thus, does she dream of decrying her own arts and manufactures, does she think of branding them inefficacious? Who dare so charge? Yet this is the language of the Belgian steel makers, in reproaching the Administration with discriminating against home industry, because, responsible as it is to the country for the good condition of its armament, it purchases abroad guns of metal and ballistic qualities not procurable in Belgium.

And yet the authorities who do use home-made steel for suitable purposes, such as small arms, gun-carriages, etc., act precisely as they do in Germany, and everywhere else; they purchase Krupp crucible steel guns from Krupp, because no where else can they receive the assurances of that degree of perfection which the science of war demands so imperatively for these engines of destruction. Our machine builders, to be as consistent as our steel makers, should be dissatisfied with the German method; we wager they are not.

A further thought in concluding this line of argument; it is strange to listen to the oratorical demand in the name of national interest, that Government contracts

be given the steel makers and that an embargo be put upon the foreign product—fairly and squarely a sample of indirect Protection—while from the same source comes an indignant opposition to all State intervention in behalf of suffering agriculture, the chief industry of the Belgian people and this, they say, in the name of Free Trade principles.

When it is a question of purchasing guns in Germany, for the sake of the foremost interest, that of national defense, which is that of national prosperity, these seeming saints cry aloud: "The interests of our steel makers are shamefully sacrificed! The State owes them its protection."

When it is a question of imposing a light duty upon grain and cattle, they have scruples; uninfluenced by the suffering of agricultural laborers, whose interests are not theirs, in the name of this same great national interest, to which they sometimes seem blind, they pose as stern advocates of Free Trade, and in strong terms hold up for public condemnation such governmental partiality.

This would be an amusing instance of moral color-blindness, were it not so painful an exhibition of self-interest.

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We will for the moment admit that the State, under the pressure of protection for steel making, undertakes the manufacture of guns.

Large sums will have to be disbursed for plant as required by "modern science," (not that of the *Journal*

de Liége 'doctors'), thus giving the right and imposing the duty, in behalf of the taxpayers, of exacting a slight profit, be it ever so little. Can we hope for such a result? The experience of France shows its futility. Here the Administration, in order to protect in an analogous fashion national industry, has seriously involved itself financially.

Gun making has too restricted a market, especially in a country of such limited wants as Belgium; it can only flourish by aid of incessant Government subsidies. The State will soon find itself burdened with a losing speculation, which can be carried on only by further demands upon the taxpayers—who are not all steel makers—a policy injuriously interfering with more important works.

And the steel makers themselves, blinded by the demand of the moment, having extended their facilities, and possibly having made costly alterations for the sake of producing a special brand of gun steel, will some day find themselves heavily stocked with unsalable merchandise!

It may be asserted that as formerly we shall have customers from abroad; this hope we cannot entertain.

No matter how capable and scientific our engineers may be, no matter what we may do, we have little prospect of ever equalling the compass or even the perfection of output of the Krupp Works, whose great *specialty* is gun making.

Sharing the foreign market with the German manufacturer, stand the Armstrong, Whitworth, Saint-Chamond, Creuzot and other Works.

Will the prospect of receiving orders from the republics of Hayti or San Domingo or other Moroccos keep in activity (is *activity* the proper word?) a great plant with its extensive personnel? Evidently, No.

As the strongest argument it is asserted that in purchasing guns abroad, we risk finding ourselves unprovided therewith, in time of war, should the contractor belong to a Power with whom we may have disputesto settle.

First, as a general proposition. "In time of peace, prepare for war." Yet, a State may be surprised, such a thing has occurred. In such circumstances, the guns ordered would be wanting, and at the critical moment too. But it would be worse to have our gun foundry, established at or about Liége, fall, perhaps fully equipped, into the hands of the enemy! Not only would he take possession of our material under construction, but also of our tools, and these, as well as our native steel, would be used in making guns to be directed against Belgian breasts!

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A page of contemporary history is here in place After the Prussian success of 1866, Napoleon III—a far-seeing potentate, to whom justice will one day be rendered—was anxious to introduce into the French army such features as had brought about the overwhelming victory of the Prussians. But under the plea that the *National* spirit, the *National* honor etc., imperatively forbade France's availing herself of the measures of a Power with whom she might some day do battle, bronze instead of steel guns continued to be

made, breech-loading was adopted only in name, official service yielded to a coalition of private interests, and as a reward for this good turn which would not accept improvements of foreign origin, the country some years later was vanquished.

The very people who then bitterly reproached the fallen Sovereign with not having the army prepared for the struggle, even if Krupp guns were required, were the self-same make-believe patriots of old !

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We conclude by appealing to our readers to weigh carefully the arguments we have adduced in support of our position.

We are not attempting to proselytize, yet we are thoroughly and honestly convinced that it is better to have superior guns, even of foreign make, than inferior Belgian.

This is the conclusion, not of a *blustering patriot*, but of a true lover of his country. We cannot win laurels in this line, but we enjoy our self-approval in the satisfaction of having done our duty.

This is sufficient praise. Belgian arts and manufactures have no need to claim the lead in everything ; they have achieved such great victories over foreign rivals, the field in which their conquering activity is displayed is so great, that they suffer no injury by being outstripped, in a single instance, by a man who is virtually the founder of modern gun making.

PERTINAX.

Brussels, August 30th, 1887.

THE DE BANGE ARTILLERY IN SERVIA.*

Our correspondent writes as follows from Belgrade under date of January 5, 1888.

During the summer of 1885, the Servian Authorities contracted with De Bange (Cail Works) for guns, gun-carriages, limbers, caissons and ammunition for the armament of the field and mountain batteries.

At the outbreak of the war with Bulgaria, the delivery of this material had not yet begun, so that the Servian Artillery was compelled to enter the campaign with its old model guns.

The opinion advanced by many, that the Servian defeat might be ascribed to these very guns, though supported by the native press of that day, is not founded on fact, as every one knows who may have had even a slight knowledge of the actual course of events. Now over eighteen months have elapsed since the Servian Artillery has been supplied with its new outfit, and we may assume that it has become thoroughly acquainted with its new weapon and its management.

The time has come then, to investigate and to see if expectations have been realized, if the newspaper laments regarding delayed delivery were well founded.

At the time the order was placed in France, about three years ago, the French press harped upon the matter in a series of self-laudatory puffs, which aroused a war of words, in which the Servian authorities were handled without gloves.

(* Translated from the Deutsche Heeres Zeitung of January 28th, 1888.)

It seems natural that these officials would have made some attempt to justify their action by the publication of reports regarding the behavior of the new guns; but up to the present time nothing has appeared; on the contrary, no effort has been spared to keep from the public all knowledge of the results of tests. The little that has leaked out, fully explains the silence of the authorities. For, if report speak truly regarding these guns, the officials would certainly be overwhelmed with ridicule.

Here is a summary of what it has been possible to learn concerning the results of trials with the new material.

1.—Guns.

About thirty pieces have already been injured by the breaking and bursting of shell and shrapnel in the bore.

In blank practice, great difficulty is experienced in opening and closing the breech.

The breech sights are too weak. The friction primers, ejected to the rear, wound the cannoneers.

2.—Gun-carriages.

The wheels are not strong enough. The springs and bolts of the gunners' seats, the brake shoes and brake shoe hooks, the eye bolts and other parts for fastening on the implements are broken; the drag chains have parted; the oilers are too light.

3.—Limbers.

The limber is not properly protected against rain and dust.

Single-trees and splinter-bars are out of shape; poles, prolonge-hooks and pole-irons are broken.

The fastenings for grease-boxes and buckets are not strong enough.

The sheet iron steps bend; the foot boards break or bend.

The pole load is too heavy.

The intrenching tools are of inferior quality.

The limber chests are badly arranged.

4.—CAISSONS.

The brake shoe is inconveniently fastened; so also the spare wheel, which is underneath, so that on uneven ground the carrier breaks.

5.—AMMUNITION.

Shell and shrapnel break or burst in the bore, or during flight.

The percussion fuze often flashes at a touch.

The time fuzes work badly; of ten sharpnel, for instance, two burst in the gun, three near the muzzle, three, at intervals up to 350 metres, one on striking, and one failed.

The scaling of the time fuzes is incorrect. The sharpnel range table is not accurate.

Even if all the defects enumerated are not of a grave nature, there are enough to justify fully the fact that the Servians are now congratulating themselves that these guns were not in service during the last war.

KRUPP'S LETTER TO "ENGINEERING."

On page 135, reference is made to Krupp's letter to *Engineering* as confirmatory of the statement that two hundred guns had become unserviceable during the Franco-German war. As a matter of interest the *text* of this letter is subjoined. It will be found in the issue of June 18th, 1875.

"With regard to the 200 guns stated to be disabled in the Franco-German war, I would offer the following remarks. I was naturally interested in a twofold manner in reference to the guns used in this war.

First, as regards the metal, and

Second, with respect to those of the guns that were made entirely upon my system of breech-loading guns, but fitted with the Broadwell form of ring. There were three systems of breech-loading used in the war with France on the German side, viz, my system, which was confined entirely to the 4-pounder guns supplied to Saxony, while all the other 4-pounders were upon Kreiner's double-wedge system, and the 6-pounders were constructed upon the Wahrendorf plan.

The 24-pounders had all the double Kreiner wedge. These all were, however, with the exception of some other guns supplied by another firm, made of steel taken from my Works.

In the material of which the guns were made I was of course interested, and not one of the guns from here burst, as it was asserted in the English Parliament had taken place, and also that not one of the guns fitted on my system of breech-loading was disabled, and in this construction alone was I interested or responsible.

That a large number of guns on the Kreiner and Wahrendorf system were disabled (not burst), is quite true, and the difference in the quality of the construction of my system, over all the others, was so marked that since the war the whole of the German field artillery has been replaced by new guns of my steel, constructed, both with regard to the gun, as well as to the breech, upon my system, but fitted with the Broadwell form of ring. The 24-pounders have also been altered from the Kreiner double wedge to my single prismatic system."

The Failure of the 14-in. De Bange Gun.

From "The Army and Navy Journal," Dec. 17th, 1887.

FAILURE OF A DE BANGE GUN.

We give here an interesting extract from the Brussels *Journal* about a matter which somehow or other has failed to attract the attention it deserves. The largest De Bange gun yet constructed—of the well known built-up type—interior tube and exterior hoops, so highly esteemed by our own millitary authorities—has failed, and failed in a manner that even the non-expert can understand. Colonel De Bange's representative enunciates the false theory of construction that underlies his system, "*but as this part of the gun is little strained.*" It seems to us a chain is no stronger than its weakest link, and that, therefore, nearly the whole length of the gun should be strong enough to resist *longitudinal* stress. In our judgment, in this lies the weak point of the French system of construction, the banding principle, too much longitudinal strain is thrown either upon the tube, or upon the somewhat delicate screw breech mechanism. This accounts for the failures of the system in England and in France:

(From the "Journal de Bruxelles.")

We announced yesterday that the beautiful De Bange gun, which excited so much admiration at the Antwerp Exhibition, had burst at Calais. Mr. I. de Macar, the Belgian agent of the Cail Company (of which Col. De Bange is Superintendent), conceives himself

injured by this simple announcement. He has written us a letter in regard to the matter, and threatens a libel suit. We reply to our correspondent that we have mentioned neither him, nor his Company, nor his method of construction, nor his Superintendent; we have merely given an item of news, and have said nothing wounding to Col. De Bange, (a burst gun usually wounds only its cannoneers). The De Bange gun is a product of industry—not a person. However, to oblige Mr. de Macar, who is a nice gentleman, we will give "literally," as he demands, the essential portion of his letter. We omit only so much of his letter as refers to the press; this, on its part, can also invoke the law. Here, then, are Mr. de Macar's explanations:

"The 14-inch De Bange gun was subjected at Calais in August, to a series of experiments to determine its qualities. This model was intended to fire a 925 lbs. projectile, with a velocity of 2,030 feet without straining the gun, or giving greater pressures than 35,000 lbs. The carriage stood the test without the slightest injury, although its strength was doubted, considering the small weight of the gun. The primers worked well, completely closing the vent, and being easily extracted by hand. It must be noted that these results have been obtained with a gun weighing only about 41 tons, that is only about 88 times more than its projectile, while similar French marine and foreign guns weigh twice as much, and, further, in these guns, the pressures exceed 35,000 lbs. On the 4th of August the experiments were about ended, and there remained only five rounds to be fired, when a regrettable accident happened to the

gun, without, however, invalidating any of the conclusions just mentioned. Here are the facts. During the hammering and assembling, Col. De Bange noticed a weak spot at about the middle of the tube ; but as this part of the gun is little strained, and as he was pressed for time on account of the approaching opening of the Antwerp Exposition—where the gun was to be exhibited —Col. De Bange gave the order to finish the gun.

" The tube parted at this very point—on the third round of Aug. 4; there were no bursts. The metal, of the tube, held by the frets, did not fly—a proof of the excellence of the hooping method used. The firing was under an angle of 10 deg.; the first two rounds gave a range of 9,300 yards, and the third, at which the gun ruptured, only 200 yards less.

" This accident is of no moment as regards the qualities of the system. A new gun of the same type is now under construction, and will soon appear on the proving ground."

Mr. de Macar admits the " regrettable accident," but seeks to explain it away as advantageously as possible for his employers. The public will appreciate.

ACCIDENTS TO FRENCH STEEL GUNS.

Colonel De la Rocque cites ten instances of mishaps to French guns, as compared with thirteen to Krupp. These latter have been examined in the text, and to complete the tale it may be well to enter into some details as regards the former.

The ten instances referred to by Col. De la Rocque relate only to the Marine Artillery, and this small number of accidents to all-steel guns is not surprising, as this model was but recently adopted.

Col. De la Rocque does not say much regarding this latest method of construction adopted for heavy guns, and since the publication of his book, at least two other accidents to these guns have come to public notice. We refer to the first two 42 cent. steel guns, which burst in the chase during proof at Ruelle in October, 1885. (*France militaire*, Oct. 11th, 1885.) Not a single accident to guns made by the War Department, or at private shops, is included in Col. De la Rocque's list. It is difficult to glean particulars concerning these other mishaps, as lately, the French press, inspired by a very laudable patriotism, has mantained a discreet silence on these matters. As an example, we need only cite the fact that the De Bange 14 cent. gun failed at Calais, August 4th, 1887, and the first notice of the failure appeared in the newspapers, October 11th.

We are however, enabled to cite, based upon statements in trustworthy papers, some mishaps to French field-guns.

In *France militaire* of July 5th, 1885. we read; "Cercottes, June 30th. A serious accident, which might have had lamentable consequences, occurred yesterday on the practice ground.

Several batteries were practising, when a piece burst. A soldier, whose name we did not learn, was seriously wounded in the face, and three horses were killed by fragments of the breech. Now if our memory serves us, a similar mishap occurred at Castres, hardly six weeks ago, and if our information be correct, these accidents were ascribed to the fact that *practise* guns were used. ....These practise guns were used for the first time during the exercises of 1884, and gave satisfaction; though in the 18th Brigade, *a case of unbreeching occurred due to the tearing out of the tube of a 9 cent. gun.*"

In *France militaire* of Sept. 6th, 1885, the following is found: "Hardly a week ago, *France militaire*, after having spoken of the bursts of *practise guns*, bursts which happen oftener than is generally supposed, announced the unbreeching in blank firing of an 8 cent. De Bange gun during cavalry exercises at Chalons, Lieutenant L. Gastineau was struck in the breast by the breech, and died within a few minutes. This most deplorable casualty was undoubtedly due to the great hurry with which the fire was delivered to repel a charge of General Espeuilles', Cavalry. To-day, we learn of as unfortunate an accident, for it too, involved a human life, which occurred in the camp at Auvours, not far from Mans."

France militaire, of December 10th, 1885, reports another accident. "On Thursday an accident happened on the Phillippeville practise ground. During firing drill, a piece burst, aud the flying fragments killed a horse. Very fortunately, the gunners about the piece escaped injury."

For quite an interval we find nothing further in *France Militaire*, but *Gil Blas* of Sept. 14th, 1886, contains this item:

"Avignon, Sept. 12th. The manœuvres of the 15th Army Corps were marked by a terrible accident. The breech of a gun burst yesterday, and a fragment grievously wounded a cannoneer, who was immeditaely carried to the hospital, where he died some hours afterwards in excruciating agony. Another cannoneer was also badly wounded."

France Militaire, June 5th, 1887, reports as follows:

"On the morning of the 1st inst. a terrible accident occurred during the firing drill of the 5th Battalion Heavy Artillery. The breech of a 7 cent. gun, probably imperfectly locked—as has so often happened—was blown to the rear on firing the piece. Three cannoneers were shockingly mutilated.

These Reffye 7 cent. guns are provided with a safety vent-cap, "which prevents the introduction of the primer unless the breech is perfectly closed." (*Cours special á l'usage des sous-offiicers*, § *195*.) To this list must be added the failure of the 34 cent. De Bange gun, last August, a total of eleven accidents to French guns which have come to public notice in three years. This list teaches some simple lessons:

1st.—It is not so easy after all to make even good field-guns.

2d.—The test of one or two guns does not afford proof of satisfactory model or material.

3d.—French open-hearth steel, notwithstanding acceptable preliminary physical tests, does not appear to be a satisfactory gun-metal. The reasons must lie in treatment, in construction, or in both.

ACCIDENTS TO ENGLISH STEEL GUNS.

The casualties to the 6 in. gun of the *Active*, Nov. 13th, 1884, and to the 12 in. gun of the *Colossus*, May 4th, 1886, are well known. On January 28th, 1888 a 38-ton gun, of latest model, failed in proof at Woolwich. It must be borne in mind that steel guns in England date only from 1883-1884, and that experience with them has not been very extended.

KRUPP AND DE BANGE.

MULTIPLIERS

FOR

Converting French into British Measures.

	Metres into Feet.	Metres into Yards.	Millimetres into Inches.	Kilograms into Pounds.	Tonneaux into Tons.
1—	3.2809	1.0936	0.03937	2.2046	0.9842
2—	6.5617	2.1872	.07874	4.4092	1.9684
3—	9.8426	3.2809	.11811	6.6139	2.9526
4—	13.1235	4.3745	.15748	8.8185	3.9368
5—	16.4043	5.4681	.19685	11.0231	4.9210
6—	19.6852	6.5617	.23622	13.2277	5.9052
7—	22.9661	7.6554	.27559	15.4323	6.8894
8—	26.2470	8.7490	.31496	17.6370	7.8736
9—	29.5278	9.8426	.35433	19.8416	8.8579
10—	32.8087	10.9362	.39370	22.0462	9.8421

1 Centimetre=10 Millimetres=0.3937 in.=$\frac{4}{10}$ of an in. nearly.

1 Tonneaux =1000 Kilogr's=0.9842 ton=1 gross ton "

1 Kilogram =2.2046 lbs. =$2\frac{1}{5}$ lbs. "

1 Metre =3.2809 feet =1.0936 yds.= $\begin{cases} 3\frac{1}{4} \text{ feet} \\ 1\frac{1}{11} \text{ yards} \end{cases}$ " "